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Animal Care and Use in Behavioral Research: Regulations, Issues, and Applications

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Animal Care and Use in Behavioral Research: Regulations, Issues, and Applications

Based on an invited paper session presented at the 1988 meeting of the ANIMAL BEHAVIOR SOCIETY

Janis Wiley Driscoll, Editor

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PREFACE AND ACKNOWLEDGMENTS

In the past decade, there has been significant change in the attitude of the public toward the use of animals in research. This change has resulted in the enactment of legislation designed to regulate animal use and the creation of agencies and procedures to enforce it. The rapidity with which these events have occurred has left many researchers confused as to what the regulations are, which ones apply to them and what they should do to comply.

At the 1987 meeting of the Animal Behavior Society, I talked to many individuals about regulations and their enforcement. I heard a number of reports of problems that researchers were having with regulations, with inspectors and with their local animal care and use committees. It became obvious that an exchange of information on regulations and how different researchers and institutions were dealing with them would be useful for ABS members. To this end, an invited paper session was organized for the 1988 ABS meeting. The papers presented here, with two exceptions, are from that session.

The paper session was organized into three areas and that organization is also followed in this volume. The first section covers current regulations in the United States and Canada and methods for complying with them. The second section discusses some general issues resulting from the regulations. The third section describes some new methods for improving conditions for captive animals.

After the paper session, it was apparent that there were some areas that were incomplete. One of these was the application of the regulations to field research. Another involved ways in which smaller institutions could comply with regulations that were intended for large biomedical research institutions. To partially fill these gaps, we have added two papers that were not presented at the paper session. Tom Rambo and I have written a paper on establishing an Institutional Animal Care and Use Committee (IACUC) at a small institution which has been added to Section I. Gail Michener has provided an article on field research which is included in Section II.

I thank the contributors to the paper session and this volume for their excellent presentations. It has been a pleasure to work with all of them. I am sure they join me in thanking the Animal Behavior Society and specifically its Executive Committee for providing a vehicle for our ideas, for their encouragement in planning the paper session and for their concern about the care and use of animals in research and teaching. We also thank the Animal Welfare Information Center for agreeing to publish and distribute this volume.

We are grateful to the following individuals who helped in the production of this publication. For review of manuscripts: Stanley Curtis, Lloyd Delude, Jim Doherty, Thomas Hartsock, Joy Mench, Dan Michener, John Miller, Kathy Nepote, Mary Ann Ottinger, David Payne, Jeff Roberts, Harry Rowsell, Dale Schwindaman, Ray Stricklin, Stephen Suomi, Susan Wells and Wendy Westron. Special thanks go to John L. Driscoll for heroic efforts in making twelve different computer systems talk to one another; to Joy Mench for arranging the publication of these papers by the Animal Welfare Information Center; and to Jean Larson of AWIC for arranging printing and distribution.

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SECTION I: REGULATIONS

This section describes current regulations on animal care and use in the United States and Canada and offers suggestions for dealing effectively with these regulations. In talking with researchers and teachers who use animals, it is apparent that there is much confusion about what the regulations are, what the regulating agencies are, where the regulations apply and what is required in specific situations. We hope that the papers in this section will clarify these problems.

Martin Stephens begins Section I with a summary of current regulations in the United States. He makes clear what regulations apply to the care and use of animals in research in the U.S. in different situations. He clarifies the application of the Animal Welfare Act, the Health Research Extension Act and various voluntary guidelines for research in animal behavior.

The United States has attempted to control and regulate the use of animals in research with legislation and regulatory agencies. In Canada, this is being accomplished in a different way, using a voluntary system with peer review. In her paper, Gail Michener describes the Canadian Council on Animal Care and how it operates.

Once we understand the regulations and how they apply to us, we must create mechanisms for complying with them. In the United States, the main mechanism is the Institutional Animal Care and Use Committee. Joy Mench discusses the responsibilities of the IACUC and in describing the operation of the IACUC at the University of Maryland, makes many valuable suggestions about how to make an IACUC function effectively.

When one examines regulations in the United States, it is apparent that they were developed with large research institutions in mind. Such institutions usually have full-time, trained animal care personnel and veterinarians on their staffs who specialize in the care and housing of laboratory animals. Such institutions have large numbers of researchers, funded by grants, who help to finance the personnel and facilities needed for large-scale animal maintenance. The situation is quite different for smaller institutions. Here, the number of researchers is small. The number of animals does not justify the employment of animal care personnel and animals are typically cared for by researchers and their assistants. Animal facilities are usually small and often were not originally intended for animal housing. Such limitations can make it difficult for a smaller institution to establish an IACUC and meet federal regulations. Tom Rambo and I have both been involved in establishing IACUCs at our institutions and report how we solved some of these problems.

OVERSIGHT OF THE CARE AND USE OF ANIMALS IN ANIMAL BEHAVIOR RESEARCH IN THE UNITED STATES

Martin L. Stephens

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Animal behaviorists in the United States are subject to two federal laws that govern the care and use of animals in research. These laws, the Animal Welfare Act and the Health Research Extension Act, apply to all forms of biomedical and behavioral research involving animals. Animal behavior research, in particular, is also governed by various guidelines that do not have the force of law. These include guidelines promulgated by the Animal Behavior Society as well as by other societies that are taxonomically oriented such as the American Society of Mammalogists. These guidelines can play an important role because in many respects they are more relevant to animal behavior research than the governing legislation which was enacted with standard biomedical research in mind. Most biomedical research is conducted under highly artificial conditions in the laboratory and on a handful of species purposely bred for research. On the other hand, much animal behavior research is conducted under naturalistic conditions either in the wild or in outdoor enclosures and on a wide variety of "wild" species.

Of course exceptions exist, but given these general differences between biomedical and behavioral research, animal behaviorists can be at a loss to design their studies to comply with federal regulations and conversely, review committees established under the regulations can be equally frustrated in evaluating proposals for animal behavior research. Hence the importance of the guidelines. This paper provides a brief introduction to the laws and guidelines governing the care and use of animals in animal behavior research in the United States.

ANIMAL WELFARE ACT

The Animal Welfare Act (AWA) regulates the care and use of animals in research and a variety of other activities. First passed in 1966, the AWA was amended and broadened in 1970, 1976, and 1985. The most recent amendments, known as the Improved Standards for Laboratory Animals Act (Public Law 99-198) (U.S. Congress 1986) significantly broadened the AWA's provisions on animal research. Although passed in December 1985, these amendments are not legally enforceable until the U.S. Department of Agriculture (USDA) (the agency that enforces the AWA) issues

final regulations on these provisions. As of February 1989, the agency had yet to do so. Regulations for some of the amendments were issued in March 1987 in proposed form only (USDA 1987).

The AWA applies to biomedical and behavioral research but specifically excludes agricultural studies related to food and fiber production. The 1985 amendments extended the AWA to include animal-based teaching in addition to research. The AWA covers all "warm-blooded" vertebrates, namely birds and mammals. Nevertheless, the USDA has decided not to extend the protection of the AWA to birds, horses, "farm animals" (e.g., pigs and cows), mice and rats. According to the proposed regulations for the 1985 amendments, the exclusion of mice and rats applies only to laboratory bred individuals. However, the actual definition of "animal" in these regulations makes no distinction between laboratory bred or non-laboratory bred. The final version of these regulations may clear up this uncertainty.

The AWA itself is a relatively short document (seven pages) that outlines the law's intent and directs the Secretary of the USDA to write regulations for implementation. The current regulations, which are being revised in light of the 1985 amendments, are over 63 pages long, single spaced. These regulations (specifically, those related to research) are what research institutions and individual investigators should follow. The regulations contain minimum standards for housing, sanitation, husbandry, veterinary care, physical plant and other aspects of a laboratory animal care and use program. They have little to say about actual experimental manipulations, much to the dismay of animal protectionists and to the delight of researchers.

The 1985 amendments were the first to address what could and could not be done to animals as part of experimental procedures. They prohibit the use of paralytic drugs without providing pain relief simultaneously. They prohibit the performance of more than one major surgical procedure on the same animal. They call for appropriate pain relief during (as well as before and after) manipulations. Of course, for these provisions and many others, the AWA allows exemptions based on scientific necessity. The 1985 amendments also mandate exercise for laboratory dogs and the housing of nonhuman primates in physical environments that promote their psychological well-being. The psychological well-being provision has been controversial (Holden 1988). Animal protectionists have hailed it as an opportunity to reform the prison-like conditions of many laboratory environments. Many researchers, on the other hand, have criticized it as vague, unnecessary and costly.

Perhaps the most significant provision of the new amendments is a mandate for research facilities to establish review committees known as Institutional Animal Care and Use Committees (IACUCs). The key responsibilities of these committees are to review proposals for research and to conduct

semi-annual inspections of facilities. The details of these reviews and inspections will be formulated in the forthcoming regulations.

Although Congress and the USDA have delegated a significant level of oversight authority to IACUCs, the USDA does conduct unannounced site visits of research facilities. It has the authority to bring legal action against alleged violators. Such actions are taken against research facilities infrequently, but can result in cease and desist orders (which apply only to violations, not entire research projects) and fines. The division within the USDA that enforces the AWA has been the Animal and Plant Health Inspection Service (APHIS). However, the USDA has recently undergone an administrative reorganization. The AWA is now administered by the office of Regulatory Enforcement and Animal Care.

HEALTH RESEARCH EXTENSION ACT

The Health Research Extension Act (HREA) is a lengthy law that reauthorized the continued existence of the National Institutes of Health (NIH). It contains a section entitled "Animals in Research" which governs the care and use of vertebrate animals in research funded by the NIH and its parent organization, the Public Health Service (PHS). The provisions of the HREA (Public Law 99-158), enacted in November 1985, are reflected in the PHS *Policy on Humane Care and Use of Laboratory Animals* (Office for Protection from Research Risks 1986). The policy describes administrative procedures that research institutions must follow in order to receive PHS grants. The policy was revised in September 1986 to incorporate provisions in the HREA. For ease of reference, the relevant section of the HREA was reprinted in the policy booklet. By law, the policy applies only to research projects funded by the PHS. However, many research institutions elect to apply the policy to all of their vertebrate-based projects including teaching programs as long as at least some of their research projects are indeed PHS-funded. This decision may seem unwise for research institutions that presumably want to free themselves from regulations. In practice, however, applying a set of standards to some projects and not others can be unworkable. Much animal behavior research is not PHS-funded and therefore, depending on institutional policy, may not be subject to PHS policy. Nevertheless, PHS policy may still apply because the National Science Foundation, which <u>does</u> fund much animal behavior research, requires its awardees to follow PHS policy.

The key element of PHS policy from an investigator's perspective probably is the mandate for an Institutional Animal Care and Use Committee (IACUC). According to PHS policy, IACUCs should be composed of at least five members: a veterinarian, a scientist experienced in animal research, a nonscientist, an individual unaffiliated with the institution and unspecified others. The principal responsibilities of these committees are

similar to those for such committees under the Animal Welfare Act: (1) to review applications and proposals for research and (2) to evaluate the institution's animal care and use program and inspect facilities every six months. Other committee responsibilities include reviewing concerns regarding animal care and use, making recommendations regarding animal care and use to the responsible institutional official and suspending PHS-supported activity as necessary. Such suspensions are mandated when a significant deficiency (defined as "a situation which is or may be a threat to the health or safety of animals") goes uncorrected.

Perhaps the most significant IACUC responsibility from the investigator's perspective is the review of proposed research projects, a process known as 'protocol review.' Protocol review and other features of PHS policy apply only to projects involving vertebrate animals. IACUCs are required to review those sections of protocols that are related to the care and use of animals. Important items to assess include the experimental manipulations themselves, as well as analgesia and anesthesia, euthanasia, environmental conditions in the animal quarters, veterinary care and personnel qualifications. At least one member of the committee must conduct the review and experts who are not on the committee may be consulted. Committees are also required to review significant changes in previously approved protocols and review all ongoing projects at least once every three years.

The PHS requires that IACUCs assess adherence of protocols to the National Institute of Health/National Research Council *Guide for the Care and Use of Laboratory Animals* (NIH 1985). The *Guide* addresses housing, sanitation, husbandry, veterinary care, personnel qualifications, physical plant and a variety of other topics. Last revised in September 1985, the *Guide* is intended to be interpreted as a flexible document that does not preclude professional judgment. Deviations from the *Guide*, however, should be justified to the satisfaction of the IACUC. The *Guide* also is the principal reference used by the American Association for the Accreditation of Laboratory Animal Care (AAALAC) to assess compliance with its voluntary accreditation program for research institutions and related facilities. AAALAC is a nongovernmental organization formed to promote high quality animal care and use. A key element of the PHS policy is self-monitoring through IACUCs. Nevertheless, the PHS, through its Office for Protection from Research Risks (OPRR), does exercise oversight. OPRR implements and interprets PHS policy, evaluates compliance, and conducts site visits, among other activities.

FIELD RESEARCH GUIDELINES

Neither the HREA nor the AWA exempts field studies from protocol review. Unfortunately, neither act provides much if any guidance to committees on evaluating proposals for field research. The National Science Foundation (NSF) attempted to

fill this void, not only to aid IACUC members, but also to provide guidance to the researchers themselves. It asked several zoological societies to devise guidelines for fieldwork on vertebrate animals. Four sets of guidelines were produced: mammals (American Society of Mammalogists 1987); birds (American Ornithologists' Union 1988); reptiles and amphibians (American Society of Ichthyologists and Herpetologists, The Herpetologists' League & Society for the Study of Amphibians and Reptiles 1987); and fishes (American Society of Ichthyologists and Herpetologists, American Fisheries Society & American Institute of Fisheries Research Biologists 1987). For an overview of the complete set of guidelines, see Orlans (1988).

The guidelines discuss methods of capturing, marking, transporting, housing, biopsying, killing and/or releasing wild animals. These documents are a modest first step. They admittedly are largely a compendium of prevailing practices and will need to be revised as field methods and ethical standards evolve. Two considerations are important for animal behaviorists to keep in mind. First, adherance to these guidelines will not guarantee acceptance of protocols by IACUCs. IACUCs may have stricter standards especially regarding field work on mammals. The mammology guidelines endorse a number of practices that IACUCs may find offensive including killing by drowning, shooting or traumatizing and capturing in leghold traps. The drafters of the mammology guidelines recognized that mammologists may encounter public-relations problems. The guidelines state "...it is good practice to be discreet in all activities that may affect the sensibilities of laymen" (p. 16). A second important consideration is that these guidelines were produced by the various professional societies, not NSF or NIH. Although NSF requested that these guidelines be drawn up, it has not endorsed them nor did it intend to do so.

The Association for the Study of Animal Behaviour and the Animal Behavior Society (1986) have jointly issued guidelines for conducting research either in the laboratory or in the field. These guidelines are common-sense recommendations for mimimizing both the numbers of animals used and any pain resulting from use. The guidelines also discuss enhancing the well-being of research animals. The guidelines are voluntary but are employed by the editors of the societies' journal, *Animal Behaviour*, in judging the acceptability of manuscripts.

DISCUSSION AND SUMMARY

This survey presents only brief summaries of the various laws and guidelines that regulate the care and use of animals in animal behavior research in the United States. Animal behaviorists are encouraged to obtain copies of the actual laws, regulations and guidelines or consult with their IACUCs for further information. Researchers should also consult with federal and state wildlife agencies regarding wildlife laws that may pertain to their work.

Investigators in all fields of animal research should bear in mind that implementation of the newer provisions for animal welfare such as protocol review is still in the formative stages. IACUCs are still groping with many difficult issues such as the feasibility and merit of conducting inspections of field research sites. Investigators should work with IACUCs to help tackle existing problems. In justifying experiments to IACUCs, investigators should realize that the regulations and guidelines were designed to address primarily animal welfare concerns as distinct from conservation concerns. Research protocols should reflect the emphasis on animal welfare.

Finally, several important considerations arise as a consequence of the fact that much of animal behavior research is not biomedically oriented. First, animal behavior studies often are irrelevant to a cardinal operating principle of protocol reviews, namely balancing potential harm to animals against potential benefits to human beings. Consequently, animal behaviorists may find it difficult to gain IACUC approval for particularly harmful or painful studies. Second, animal behaviorists conducting studies of animals in captivity will often want naturalistic conditions. This may invite trouble with USDA inspectors who may want a different balance struck between standard laboratory conditions and field conditions. The new emphasis on psychological well-being, although legally limited to non-human primates, should help researchers argue their case even for studies of animals other than primates.

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SURVEILLANCE OF ANIMAL CARE AND USE IN CANADA

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The Canadian Council on Animal Care (CCAC) is the agency responsible for monitoring the welfare of animals used in research, teaching and testing by universities, government agencies, and private facilities in Canada. Detailed descriptions of the history, principles and operations of the CCAC appear in a two-volume guide published by the CCAC (1980, 1984); in Rowsell (1986, 1987, 1988); and in pamphlets available from the CCAC (151 Slater Street, Ottawa, Ontario, Canada K1P 5H3). In this article I outline the functioning of the CCAC with emphasis on the Canadian choice of a voluntary versus legislated system of surveillance of animal care.

The first organized steps toward controlling and upgrading the care of experimental animals on a national scale in Canada came from within the scientific community. The Canadian Federation of Biological Societies established a Standing Committee on Laboratory Animal Care in 1961 and, at the recommendation of the Medical Research Council (MRC), the National Research Council (NRC) established a Special Committee on the Care of Experimental Animals in 1964 to review the Canadian situation. In the opinion of the NRC committee, optimal conditions for animal care and use were more likely to be achieved in Canada through a voluntary control program with peer review rather than through a legislated control program with government inspection. The NRC committee recommended that a national advisory body, independent of any government agency, be established under the aegis of the Association of Universities and Colleges of Canada (AUCC). Following a feasibility study commissioned by the AUCC and endorsed by universities and government departments, the Canadian Council on Animal Care was founded in 1968 as a standing committee of the AUCC with financial support from the Medical Research Council and the National Research Council. In 1983, the CCAC was incorporated as an autonomous agency.

The mandate of the CCAC includes monitoring and improving the procurement, production, care and use of experimental animals. Initially, the CCAC defined an experimental animal as "any vertebrate animal that is separated from its natural environment and utilized in research, teaching and testing" (CCAC 1980, p. i). However, Volume 2 of the Guide (CCAC 1984) has a chapter devoted to the use of wild vertebrates and the Categories of Invasiveness accepted by Council in March 1988 includes invertebrates. Thus, the purview of the CCAC is not restricted to the limited number of species, mostly avian and mammalian,

used in biomedical research but extends to all species in captivity and in the field, to animals used in universities and community colleges for teaching purposes and to animals used by government and private agencies for testing purposes.

From its inception, surveillance of the care and use of animals in research, teaching and testing in Canada has been based on the concept of voluntary adherence to ethical codes of practice found generally acceptable by the scientific community, the humane societies, and the general public. The rationale for the voluntary versus legislated program involves the following perceptions: 1) a voluntary system aims to achieve optimal conditions whereas a legislated system tends to implement only the minimally acceptable conditions embedded in law; 2) a voluntary system is more flexible and responsive to changing knowledge and opinion on optimal care because it does not involve the lengthy process of rewriting legislation; 3) peer assessment panels drawn from a national base of scientists can be tailored to the types of animal research conducted at each institution, whereas a government inspectorate has a more narrow selection of expertise; 4) a voluntary assessment system is based on the genuine commitment of individuals prepared to serve without remuneration, whereas a government inspectorate depends on paid civil servants; 5) peer review permits flexible interpretation of guidelines suited to each institution's situation whereas government inspection tends to enforce application of legislated standards even when inappropriate to a particular institution or research program; 6) a voluntary system with no compliance or licensing costs can be equitably applied to institutions of different sizes and nature whereas under a legislated system some establishments, particularly small institutions with a minimal research component, may find compliance to rigid laws impossible to fulfill. The voluntary system is also suited to Canada because it avoids constitutional conflict between federal and provincial authority and because it suits the Canadian psyche of achieving ends through cooperation and compromise rather than imposition and confrontation.

As of October 1988, the CCAC comprises 22 representatives from 18 agencies. Six of these agencies are professional societies that represent researchers and teachers in academic institutions (e.g. Association of Faculties of Veterinary Medicine in Canada), four represent granting agencies (e.g. National Cancer Institute), five represent government research and testing facilities (e.g. Health and Welfare Canada), one represents animal care workers (Canadian Association for Laboratory Animal Scientists), one represents private industry (Pharmaceutical Manufacturers Association of Canada) and one represents animal welfare interests (Canadian Federation of Humane Societies, CFHS). The AUCC has four representatives on Council, the CFHS two and all other agencies one each.

The CCAC is responsible for developing and continually updating guidelines for the care and use of experimental animals, and for ensuring that each institution has an effective and

operational animal care committee (ACC). The CCAC sends assessment panels on periodic site visits to each Canadian institution using animals in research, teaching or testing. It encourages appropriate education of those who work with animals (CCAC 1985; Flowers 1987).

Throughout its 20-year history, the CCAC has directly involved the Canadian Federation of Humane Societies in its operations. In addition to representation on the Council itself, a Federation appointee is included on each assessment panel. The CFHS, is the largest, national animal welfare organization in Canada, representing 200,000 members. It publishes a guide for laypersons who serve on instiutional animal care committees (CFHS 1986). The voluntary versus legislated system of animal surveillance in Canada has been queried and criticized by some in the animal welfare movement (Clark 1987).

The first level of surveillance in the Canadian system is by an animal care committee within the institution. Precise size and membership of these intramural committees vary according to the needs of the institution but the recommended minimal composition is: 1) senior scientists experienced in care and use of animals; 2) a veterinarian; 3) a non-user of animals from within the institution; and 4) a layperson representing community interests and concerns. Other expertise can be co-opted as necessary when a committee requires additional input. Local animal care committees operate under senior levels of administration within the institution, typically the president or vice-president (academic) in an academic facility. Responsibilities of the local animal care committee include: 1) reviewing all protocols for the use of animals; 2) conducting regular visits to facilities in the institution; 3) ensuring adequate care of all animals in accordance with CCAC guidelines, and 4) terminating procedures that violate the CCAC guidelines. The goal of a good committee is not to be viewed as policing animal use in a confrontational manner but to be viewed as facilitating work within the institution by acting cooperatively with animal users and the administration to achieve the common goal of maximizing the welfare of animals.

The second level of surveillance in Canada is via CCAC assessment panels that conduct on-site visits. A pre-announced visit is made to each institution at least once every 3 years; unannounced visits can be made at any time and special visits can be made at the request of the institution or of the Council. Assessment panels are drawn from a list of scientists prepared by the CCAC Director of Assessments and from a list of CFHS appointees. As already noted, each panel is uniquely constituted with panelists selected according to the predominant thrust of research at the institution to be assessed. The average complement of an assessment panel is three scientists and one CFHS representative with the Director or an Assistant Director of Assessments from the CCAC as an ex officio panelist. Institutions do not have the right to select panelists but they do have the right to refuse a panel member for perceived bias.

Panelists serve voluntarily; travel expenses are paid by the CCAC but no remuneration is given. Panelists may not reveal information acquired during a site visit, e.g., regarding an institution's facilities or research programs. The role of the panelist is not that of an inspector in the traditional sense of the word but of a colleague whose goal is to provide support aimed at helping the local animal care committee and the local administration achieve high standards of animal care.

Prior to the site visit, the assessment panel reviews information provided by the institution concerning animal facilities, species and numbers of animals housed and the nature of projects being conducted. To facilitate acquisition of this information, a computer program has been developed (Flowers & Ironside 1989). During the site visit, the panel meets with the local animal care committee and senior officials, visits areas in which animals are housed or used and interviews investigators and animal care technicians. Following the site visit, panelists prepare a written report summarizing their observations and, as necessary, make recommendations for improvements in animal care. Before submission to the visited institution, the assessment report is reviewed by all Council members thereby ensuring uniformity in the application of CCAC guidelines to institutions visited by different assessment panels. The institution is required to provide the CCAC with an implementation report within 6 months of receipt of the panel report. If an institution fails to fulfill recommendations of the report adequately and in a timely fashion, the CCAC can class the institution as being in non-compliance and the institution is notified that the facility or project responsible for the non-compliance status be closed or terminated by a specific date. Failure to respond appropriately to the non-compliance notification results in major granting agencies being informed of the continuing status of non-compliance. The two major Canadian granting agencies (the MRC and the Natural Sciences and Engineering Research Council) can freeze or withdraw research funds for any or all research programs at that institution not just those programs directly related to the non-compliance status.

Relatively little legislation pertinent to the use of experimental animals exists in Canada (Rowsell 1988). Three Canadian provinces (Alberta, Ontario, Saskatchewan) have legislation dealing with procurement of animals, particularly dogs, for research. Alberta and Ontario are the only provinces with legislation that requires government inspection of research facilities. The only national legislation that pertains to animal care and use appears in Section 402, Cruelty to Animals, of the Canadian Criminal Code. In 1985, this section of Canadian law was used to charge two individuals at a Canadian university with cruelty for the restraint of a baboon. However, the case was withdrawn by the plaintiff before a legal judgement was reached. The Canadian Law Reform Commission has drafted a new Criminal Code which includes an explicit provision for scientific experiments incorporating the concepts of proportionality and necessity, viz. the pain and injury caused must be justifiable

in terms of the object pursued and no alternative research techniques are feasible. Linden and Barnes (1988) noted that the decision to pursue a voluntary versus a legislated scheme is a political rather than a legal matter because the arguments for and against each method are fairly evenly balanced. Further, they caution that regulatory legislation does not necessarily guarantee improved animal care, is rendered ineffective without adequate funding and government will, and may merely placate critics without maintaining adequate or disinterested controls. The role of the CCAC is currently under review by the Medical Research Council. That review will reveal if public attitudes and political will continue to find the current system of non-legislated controls acceptable.

Although the CCAC has no legislative power to terminate procedures or close facilities that violate the CCAC guidelines, the Canadian system of peer review and voluntary compliance has proven effective in persuading researchers and institutions to adhere to the guidelines. All institutions found in non-compliance since the start of this program in 1984 have responded appropriately and had their non-compliance status removed without the CCAC having to inform granting agencies. This responsiveness stems from the perception within Canada that the CCAC is not a policing body per se, but an agency that aims to facilitate the use of animals in research, teaching and testing within the limits deemed acceptable by scientists and society. Thus the CCAC aims not to threaten institutions into compliance but to persuade investigators and adminstrative officials that compliance is in the mutual interests of the animals, the animal users and the institution. Improvement of animal care and welfare thereby becomes a mutual and cooperative effort that minimizes advocacy and confrontation.

SUMMARY

Surveillance of the care and use of animals for teaching, research and testing in Canada is the responsibility of the Canadian Council on Animal Care (CCAC), a non-governmental autonomous advisory and supervisory body established in 1968 and funded by the Medical Research Council and the Natural Sciences and Engineering Research Council. The fundamental concept on which surveillance is based is that of peer review exercised intramurally by a local animal care committee and extramurally by periodic site visits from CCAC assessment panels. The underlying principle of the surveillance program of the CCAC is that animal care can be most effectively and efficiently improved through voluntary compliance with the continually-updated guidelines of the CCAC via the joint efforts of animal users, local animal care committees and the CCAC. The CCAC attempts to be cooperative rather than confrontational in achieving compliance to its guidelines.

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INSTITUTIONAL ANIMAL CARE AND USE COMMITTEES: MAKING THEM RESPONSIBLE AND RESPONSIVE

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As a result of the publication of the Public Health Service Guidelines and the passage of the federal Animal Welfare Act, most organizations conducting research or testing using animals are required to establish Institutional Animal Care and Use Committees (IACUCs). Responsibilities of the IACUC may include the review of animal care portions of grant proposals and other proposed research, inspections of animal facilities and the review of practices within the institution involving animals to ensure compliance with federal and state laws. Within these constraints, however, there is considerable latitude in the way in which IACUCs can function. Whether or not IACUCs can succeed in fulfilling their regulatory and advisory roles while remaining responsive to the needs and problems of animal researchers depends on many factors including committee composition, institutional policies and the attitudes of committee members. Topics addressed in this paper include suggestions as to how IACUCs can interact effectively with researchers as well as a description of the structure and procedures for protocol review used by the IACUC at the University of Maryland, College Park.

FEDERAL REGULATIONS

The establishment of IACUCs is mandated by two sets of federal regulations; the Public Health Service (PHS) Guidelines, as detailed in the NIH *Guide for Grants and Contracts: Laboratory Animal Welfare* (1985), and the Animal Welfare Act (1966; amended in 1970, 1976 and 1985). These regulations are reviewed in detail elsewhere in this volume (Stephens) and will be discussed only briefly here.

The PHS Guidelines apply to the use of vertebrate animals in biomedical research, research training or testing at all institutions which receive funding from either the Public Health Service or the National Science Foundation. Under these Guidelines, committees (which must be comprised of at least five members including a veterinarian, a practicing scientist, a non-scientist and a non-affiliated member) are required to inspect animal facilities semi-annually, evaluate the institution's animal care program annually, review the animal care portions of grant proposals and provide a continuous forum for concerns related to animal use at the institution. The Animal Welfare Act applies to all institutions which use

warm-blooded animals (with some specific USDA exclusions such as laboratory rats and mice, birds, and agricultural animals) in teaching, research and testing. The Act specifies that the IACUC have a minimum of three members, to include a veterinarian and a non-affiliated member, the latter intended to represent "general community interests" in the care of animals. Under the Act, the IACUC is required to conduct semi-annual facilities inspections, evaluate proposed research projects using animals and review the "condition of animals" and "practices involving pain" to animals at the institution.

WHAT MAKES AN IACUC SUCCESSFUL?

It is important to stress that the regulations and guidelines referred to above permit substantial flexibility with regard to committee structure and function. The attitudes of committee members regarding their regulatory responsibilities, and the resultant institutional policies that the committee establishes are crucial in determining the IACUC's success. Researchers feel that they are becoming increasingly enmeshed in bureaucracy and may therefore react negatively to further regulation, viewing it as an infringement of academic freedom. Because of this climate, members of IACUCs can experience difficulty finding the middle ground between being perceived as confrontational or obstructive and serving only as "rubber stamps" for animal research.

It is, of course, essential that a strong commitment to optimizing animal well-being underlie all policies, deliberations and decisions of the committee. I would like to suggest, however, that committees can accomplish their regulatory and educational functions most effectively if they also view their role as one of assisting investigators in three crucial areas; compliance with regulations and guidelines, public accountability and improvement of the institutional animal care program.

Compliance with Regulations and Guidelines

With the explosion in the number of journal articles, most researchers find themselves too busy keeping abreast of the scientific literature to have much time for leisure reading like the *Congressional Record*! IACUCs should develop a mechanism for monitoring current and pending state, federal and local legislation which is likely to affect animal researchers. In consultation with institutional lawyers and/or governmental officials where appropriate, the IACUC can then formulate carefully considered institutional policies relating to those regulations. Committees should strive to make compliance as clear-cut and straightforward as possible since this will greatly facilitate cooperation between the IACUC and investigators.

Public Accountability

The increasing demand for accountability in science, combined with recent adverse publicity about animal research, has made it imperative for institutions at which animals are used to develop a means of responding to public concerns. The IACUC, in conjunction with institutional lawyers and public relations staff, can act in this capacity on behalf of both individual researchers and the institution. Perhaps most importantly, committees should have clear and widely publicized procedures which enable "whistle blowers" to communicate with IACUC members. This enables the committee to deal with problems quickly and internally to the benefit of both investigators and the animals concerned. In addition to reacting to problems and concerns, however, the IACUC can also take an active educational role. For example, members can serve as speakers for schools and community groups on animal care issues. At College Park, our committee is producing a video to be shown to students in introductory biology courses which will present information about the benefits of animal research and the role of the IACUC on campus. In addition, we are considering sponsoring a one-day meeting for state and local legislators which will not only incorporate a tour of our animal facilities but will also provide an opportunity for these individuals to meet with IACUC members and the Director of Laboratory Animal Care and discuss the campus animal care program (and animal welfare issues in general) in detail.

Providing the Highest Possible Quality of Animal Care

While there are many elements of a quality animal care program, there are three fundamental areas where committees can be of particular assistance. The first of these is in obtaining institutional support. Committees can act as a effective liaison group between researchers and administrators in conveying the importance of establishing and maintaining a quality animal care program. The institutional support obtained should be both moral and financial, the former expressed as a strong, public commitment emphasizing the importance of animal research within the institution. With regard to financial support, IACUCs should provide detailed and prioritized lists of current facility, personnel, equipment, security and program needs at the institution as well as anticipating future requirements. In this regard, it is also helpful if the committee can develop a consultant relationship with an architect to ensure that animal quarters in planned buildings conform to NIH guidelines for facility design and construction.

The second need is for the IACUC to assist in developing relevant training programs for animal care technicians, students and principal investigators. Ideally, these programs should go beyond the minimum requirement of informing animal users about policies and regulations to incorporate training in animal care and handling, new and/or improved techniques and alternative models. In addition to providing hands-on training, the

establishment of a library of instructional books and videotapes dealing with anesthesia, euthanasia, surgical techniques and animal management and welfare can be of great benefit. Training programs of this type require funding and personnel and may therefore be difficult to establish, particularly at small institutions. Committees can broaden their training capabilities considerably, however, by making use of the expertise and resources of national organizations. The Animal Welfare Information Center at the National Agricultural Library, for example, distributes bibliographies, documents, and audiovisual training materials on animal care and welfare free of charge through the interlibrary loan system.

Finally, there is the peer review of research and teaching involving animals (known generally as "protocol review"), probably the single most important function of IACUCs. Principles and methods of protocol review have been discussed in detail elsewhere (Orlans 1987a). In general, however, IACUCs are best qualified to review teaching and research activities for the appropriateness of animal use, not for overall quality. Russell and Burch (1959) have proposed three general questions as criteria for humane experimentation which can serve as a guide for committee evaluation of protocols: 1) can animals be <u>replaced</u> with non-animal models or with animals lower on the phylogenetic scale (but see J. Mather's discussion in this volume); 2) can the number of animals used be <u>reduced</u>; and 3) can experimental design and techniques be <u>refined</u>. Committee members may also find reading case studies of protocol reviews by other IACUCs instructive (Orlans 1987b; case studies are also regularly published in *Lab Animal*). Review of this kind not only improves animal well-being, but can also help investigators to substantially improve the quality of their research and increase their probability of obtaining extramural funding. It can also have unexpected bonuses. The committee at my institution, for example, has on several occasions fostered productive collaborations between investigators who, on our large and fragmented campus, might not otherwise have realized how complimentary their research interests were.

In order to accomplish the goals outlined above, IACUCs should have a respected, committed and diverse membership, a well-organized and well-documented animal care program with clear lines of administration, and established procedures for reviewing research and teaching. In the remainder of this paper, I will discuss the way in which we have structured our committee at the University of Maryland in an attempt to be both responsible and responsive to researchers' needs.

THE IACUC AT COLLEGE PARK

The University of Maryland College Park Campus is a branch of a large public institution with an enrollment of approximately 37,000 graduate and undergraduate students. An animal care committee has been in existence on our campus for

more than 15 years but committee structure and procedures were only fully formalized in 1985. At this time the *Guidelines for Animal Use on Campus* (1985), which were published by our Graduate School, were presented to the campus community in a series of seminars. The *Guidelines* included information not only regarding the administration of and procedures involved in complying with the campus animal care program, but additional material the Committee felt might be useful to investigators. This included copies of the *AVMA Panel on Euthanasia* (1986), the NIH *Guide for the Care and Use of Laboratory Animals* (1985) and tables of appropriate anesthetics, analgesics, and caging for all of the species used on campus compiled by the veterinarian who is our Director of Laboratory Animal Care.

There are approximately 75 animal researchers (principal investigators) on the campus; these individuals have diverse research interests involving biomedical, agricultural and zoological investigations using vertebrate animals from all classes. We have tried to structure our committee such that these diverse interests are adequately represented. Our committee contains nine scientific members drawn from each department on campus in which animals are used. Each is appointed for a single three-year term, so it is likely that many of the animal researchers on campus will eventually serve on the committee. Our non-scientific member is a bioethicist from the Philosophy department and we have two non-institutional members, one from the Humane Society of the United States (who has a doctorate in Ethology) and one from a animal care technician training organization, WARDS. There are also three ex-officio members representing the University administration including the aforementioned Director of our animal care program, an individual from the grants and contracts office and a representative of the Dean for Graduate Studies and Research, the institutional official to whom the IACUC reports. In addition, there is a separate Production Animal Subcommittee comprised of six scientists which deals exclusively with research and teaching involving agricultural animals. Other members who are not presently included on our IACUC but who can prove valuable include graduate and undergraduate students, statisticians, technicians and representatives of physical plant.

Some of the scientific members of our IACUC serve a dual role since they also act as the supervisors of their departments' animal facilities. In this capacity they directly oversee animal use within their respective departments. This structure acts to increase the interface between committee members and investigators and also makes committee members more aware of day-to-day animal care problems as well as requirements for upgrading facilities.

Our committee reviews all research and teaching activity on the College Park campus. Investigators are required to submit protocol forms on which they provide information regarding animal management, surgical techniques, anesthesia, analgesia and euthanasia as well as a justification for the use of animals in general and the particular species and numbers required.

Experiments must also be categorized with respect to the degree of invasiveness, with the lowest category (Category 1) indicating procedures involving minimal pain or distress (e.g. venipuncture, behavioral observations) and the highest category (Category 3) indicating procedures involving unalleviated pain or distress. Category systems such as ours (which is based on the USDA annual report form) or that described by Orlans (1987a) can provide IACUCs with a useful tool for protocol assessment.

All protocols on our campus receive full committee review. We deal with relatively few protocols per year, approximately 75, so this approach is feasible. The number of protocols is small because each may contain a description of multiple (related) experiments which are approved over a three-year period. The committee also encourages investigators to submit brief addenda to protocols when minor changes are proposed rather than resubmitting full protocols. Other institutions with a larger volume of protocols may find it necessary to adopt a 3-tier review system with protocols receiving either expedited, expanded or full review depending on the level of invasiveness involved.

Protocols, which must be signed by both the Department Chairman and the Facilities Supervisor (e.g., the departmental IACUC member), are first submitted to the Director of Laboratory Animal Care who checks them for completeness and who may also contact the investigator for clarification or revision. If the proposal falls into Categories 1 or 2, the Director may also, at the investigator's request, grant a provisional approval which permits the initiation of the research pending full committee review.

Protocols involving agricultural animals and biomedical animals are forwarded by the director either to the Production Subcommittee or the IACUC as appropriate. They are then reviewed in detail by at least two committee members and introduced for full committee discussion at the next monthly meeting. In general, Category 3 proposals receive the most serious and extensive review. The vast majority of the Category 3 research conducted on our campus, however, involves the production of monoclonal or polyclonal antibodies in mice and rabbits. For this reason, our committee has developed a set of standard operating procedures (SOPs) for such research; protocols which adhere to these procedures in full therefore require only brief review. Other committees may find it helpful to devise SOPs for procedures that are used frequently at their institutions such as the use of prolonged restraint, toxicity testing or particular surgical techniques. Copies of some institutional SOPs can be obtained from the Scientist's Center for Animal Welfare.

SUMMARY

IACUCs are still in a stage of transition with respect to their structures and policies, with relatively little guidance in these matters available to many committee members. Despite

having to learn several lessons the hard way (or perhaps as a result of it!), I think our IACUC at College Park has been largely successful thus far in cooperating with researchers while also establishing strict standards for animal care and use. The committee structure and procedures that will be most appropriate at other institutions will, of course, vary considerably depending on the size of the institution and the types of research and/or teaching conducted (see *Effective Animal Care and Use Committees* (1987) for discussions of organization and protocol review at several different institutions). The Scientist's Center for Animal Welfare has published eighteen consensus recommendations (1987) on IACUCs which can assist committees in general to increase their effectiveness. Most importantly, IACUCs should strive to establish and maintain a broad-based membership of respected individuals who have a strong commitment both to the improvement of animal well-being and to the future of research. Such committees are most likely to be successful in interacting with investigators and institutional administrators to provide a quality animal care program.

NOTES

1. Published as Scientific Article No. A-4880., Contribution No. 7915, of the Maryland Agricultural Experiment Station.

2. Copies of the Animal Welfare Act and amendments can be obtained from the Deputy Administrator, U.S. Department of Agriculture, APHIS-VS, Federal Bldg., 6505 Belcrest Road, Hyattsville, MD 20782.

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FORMING AN IACUC AT A SMALL INSTITUTION

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If you are a faculty member at a small institution who works with animals and who is interested in promoting humane use of animals at your institution, you know that there are federal regulations governing the use of animals in research. If you delve further into these regulations, you will find that they are not designed for small institutions where you might keep lizards in your office and rats down the hall. It is difficult to determine what regulations apply to you and your institution and what you can do to meet them. In addition, although there is agreement that compliance with regulations can be difficult for small to mid-size institutions (Gordon 1987; McKelvie 1987), there has been little discussion of how these problems might be solved. In this article, we describe how we are dealing with these problems at our own institutions.

The University of Colorado at Denver (CU-Denver) is an independent branch of the University of Colorado system. It began as a extension of the main campus in Boulder in 1912. It is located in downtown Denver and is a commuter campus. Although CU-Denver has a fairly large number of students (over 6000 full-time-equivalent students and over 10,000 headcount), about half are enrolled in graduate and professional school programs. All current use of live animals occurs in the departments of Psychology and Biology. Animals used range from fruitflies to rats with no large mammals. There are fewer than ten faculty members on campus who use animals in research or teaching and of those, only about half are involved in externally funded research. By the end of 1989, CU-Denver expects to have at least four externally funded researchers whose work falls under Public Health Service (PHS) regulations.

Northern Kentucky University (NKU) was initially established as a state college in 1968, replacing a small community college. The northern Kentucky area is the second largest metropolitan region in the state and is part of the greater Cincinnati metropolitan area. NKU became a university in 1976. Its primary mission is as a four-year undergraduate institution although it does have a law school and offers Master's degrees in education and business. NKU currently has about 300 faculty members serving over 9000 students who are

mostly commuters. The first buildings on the new Highland Heights campus opened in 1972 and construction is still continuing. Virtually all use of live vertebrates is limited to the departments of Psychology and Biological Sciences. Eight faculty members use animals in research or teaching. The animals range from fish to rabbits. There are no dogs, cats or nonhuman primates.

WHO NEEDS AN IACUC?

General considerations

There are many reasons why a small educational institution may want to establish an IACUC quite apart from the need to satisfy various external regulatory agencies. These benefits may be particularly useful in convincing colleagues to cooperate with and participate in the establishment of the committee. Small colleges often pride themselves on being sensitive to contemporary issues and for providing a forum for the discussion of these issues. Certainly we should be leading the way in subjecting animal care questions to the full light of academic study and scrutiny. Having an IACUC on campus will help to give us authority and perspective to enter into the evaluation of animal care concerns. In these circumstances, the IACUC can be used as a source of information on new techniques, concerns and developments in the fields of animal welfare and research. IACUC review can help to get both students and faculty thinking about the ethical problems involved in using animals in research and teaching and can be a valuable learning experience for students, if you choose to involve them in the review process.

Small colleges are not immune from pressures from animal rights activists. Some groups even resort to anonymous accusations, innuendo and even outright fabrication. NKU was once accused of mistreating dogs, even though dogs had never been kept or used there either for teaching or research. Having an active and effective IACUC on campus with well maintained records is a good protection and provides the documentation needed for dealing with contingencies which may arise.

REGULATORY REQUIREMENTS

Martin Stephens (this volume) has clearly explained what regulations govern the care and use of research animals in the U.S. Gail Michener (this volume) has done the same for Canada. Joy Mench (this volume) has told us how to made an IACUC work at a large research institution. But what about us little guys? The results of Jack Demarest's survey of small colleges (this volume) indicate that many small institutions either are not in compliance or think they are not in compliance with federal regulations.

If there are researchers at your institution who use live vertebrate animals and who are funded -- or hope to be funded -- by the National Institutes of Health (NIH), National Science Foundation (NSF) or other federal agencies, it is best to have an IACUC. An institution can sign off on these researchers' grant proposals indicating that an IACUC will be formed if requested but how long this will work is questionable; the circumstances requiring the approval of an IACUC are becoming broader and broader. One researcher at CU-Denver was recently told that his grant proposal would not be reviewed unless it had been approved by an IACUC. We think that this statement was ultimately incorrect but it may be less stressful to form the IACUC than to deal with inconsistent interpretations of the rules by granting agencies. At NKU, the IACUC was required to approve a proposal to do field research on chimpanzees in Tanzania. If your institution has no federally-funded researchers and does not have nonhuman primates, dogs, cats, rabbits, guinea pigs, hamsters or marine mammals (species currently covered by the Animal Welfare Act), you do not technically need an IACUC. Birds, rats, mice, horses and other farm animals are excluded by regulation (U.S. Congress 1986). If, however, you and your institution are genuinely interested in the humane treatment of animals, as we hope you are, you may want to both establish an IACUC and set an institutional policy as to what animals and activities are to be reviewed by it. CU-Denver has recently formed an IACUC and filed an Assurance with NIH. The IACUC has recommended an institutional policy that all activities with animals including educational uses will be reviewed by the IACUC. This policy is written to include invertebrate as well as vertebrate animals.

WHO IS ON THE IACUC?

PHS policy requires that the IACUC have at least five members including a veterinarian, a person in a nonscientific speciality and a person not affiliated with the institution (OPRR 1986). Large institutions often have a veterinarian and/or a certified laboratory technician on the payroll. This is not the case with a small institution which usually has neither. At CU-Denver, we solicited the services of a local veterinarian who was recommended by one of our animal researchers. We pay her a small annual stipend to attend meetings, react to proposals and occasionally advise us on problems with animals. Often, a veterinarian will serve on an IACUC without pay. We felt that personnel would be more willing to seek the veterinarian's advice if she were being paid. NKU's veterinarian is also paid a small stipend. Both CU-Denver and NKU are located in urban areas, making finding a veterinarian easy. Other possibilities for finding a veterinarian include arranging for the veterinarian at a nearby larger institution to advise and occasionally attend meetings and inspect facilities. A third possibility would be for several institutions to share a veterinarian's services or even form combined IACUCs.

Finding the nonscientist is usually not a problem even at a small institution. Often a faculty member in the Philosophy department will be interested in ethics and will agree to serve. The community member can often be found through animal welfare agencies such as the local humane society. Nearby large institutions with IACUC's can also provide leads on good community representatives.

RESPONSIBILITIES OF THE IACUC

If you want your IACUC to be registered with NIH, you must file an Assurance. When CU-Denver submitted its Assurance, we were advised that Assurances are usually requested by NIH when research proposals are funded and are not often voluntarily submitted by institutions. Apparently the reason for this is that unless a grant proposal is funded, there is no need for an Assurance. However, if your IACUC evaluates a proposal for a researcher who is likely to be funded, you may want to have an Assurance ready to submit. Although NKU had an "Animal Care Committee" for many years, it was not formalized until a researcher applied for funding from by NSF. NKU is now in the process of preparing an Assurance. An example of the content and wording of the Assurance can be found in "*Public Health Service Policy on Humane Care and Use of Laboratory Animals*" (OPRR 1986) which can be obtained from PHS.

Once you have an IACUC with the proper membership, there are really only three other problems that are difficult for small institutions. Taking the easiest first, the institution must have an educational program for researchers and animal care personnel. It is unlikely that many small institutions employ full-time animal care personnel. More commonly, researchers and their assistants care for the animals themselves. The CU-Denver IACUC proposed to serve as an information source and to conduct a workshop once a year for researchers and assistants who are using nonhuman animals. This proposal was acceptable to PHS. Video minicourses can be made or are sometimes available for purchase and can be kept on hand and used whenever new individuals become involved in animal care and research. The Animal Welfare Information Center is a good source for materials.

The next problem for small institutions is that a health program for animal care personnel must be described in the Assurance. At minimum, there must be a provision for persons working with animals to have a medical examination prior to employment, emergency care must be available and instruction must be given on zoonoses, proper personal hygiene and safe handling practices to be used with animals. At CU-Denver, persons working with animals are asked to sign a statement indicating that they have had a medical examination and have been given written material on safe procedures to be used when working with animals. Emergency care is available through an on-campus clinic.

The third, and often most serious, problem for small institutions is the responsibility of the IACUC to see that animal housing facilities meet the requirements of the NIH *Guide for the Care and Use of Laboratory Animals* (1985). CU-Denver was fortunate in this regard, having recently moved into a new building with a small animal housing suite that was designed to meet the requirements of the *Guide*. Before this move, animals were housed in antiquated facilities that were not designed for animal housing in the first place and could not even come close to meeting *Guide* requirements. In circumstances like this, our advice is to, first, read the *Guide* carefully. A great deal of rumor and myth has grown up around the *Guide* and many of the "requirements" one hears about are actually only recommendations; there are "hedge statements" relating the requirements to the specific situation and needs of the institution. Also, an IACUC can develop a reasonable schedule for correcting deficiencies that does not involve building a new million-dollar facility. Administrators will often open their pocketbooks when grant funds are involved but impossible demands can lead to the elimination of animal use at an institution. Be reasonable about what you need.

If an institution is able to renovate or build new facilities, it is imperative that persons knowledgeable about the requirements of the *Guide* communicate with architects and builders and keep track of what is going on during construction. Even though both of our institutions have new facilities, it was very difficult to first, justify the need for an animal facility and second, insure that the resulting facility was consistent with regulations.

COOPERATION WITH THE IACUC

Once you have an IACUC, you will need to convince your colleagues to cooperate. Many of us who work at small institutions like them because of the independence we have. We do not like chairpersons, administrators, or committees telling us what to do. Especially if your institution sets a policy that the IACUC will review uses of animals for teaching and internally-funded research, it may be difficult to convince your colleagues that having a committee review their activities is a good idea. We think that the best approach is to emphasize how IACUC review can benefit teachers, researchers and students as we have pointed out earlier in this paper.

Another facet of our independence is that faculty and administrators at small colleges pride themselves on being able to work under a "collegial model", and this is often the model to use. The earlier we can involve anyone likely to be affected by the IACUC, the fewer problems we will encounter later. Discussing the problems and issues with appropriate departments and individuals during the establishment of the IACUC means that these people will have input into the process and will not feel that their independence or "academic freedom" has been infringed.

When this was done at NKU, we discovered that at least one department was already concerned and had a set of official policies regarding the use of animals in teaching and research within the department.

It is also very important to develop a procedure for quick review of projects. At a small institution, there will usually not be enough proposals to review to justify frequent meetings. But holding proposals for long periods of time until you have enough to justify a meeting is not feasible either. At CU-Denver, we have developed procedures for the chairperson of the IACUC to approve projects not involving pain or distress to animals with written reports to the rest of the committee and for phone votes after circulation of written proposals on other projects. A full committee meting is required only for proposals involving significant pain and distress. We also require only one review of protocols for laboratory projects that are repeated unless major changes are made in the procedures.

SUMMARY

Establishing a functioning IACUC at a small institution is not an easy job because regulations were not written with the small institution in mind. In some cases, federal regulations can cause considerable hardship and can lead to the abandonment of animal use in research and teaching. If this happens, it would, indeed "ghettoize" small institutions as Jack Demarest (this volume) has suggested.. It is important that we avoid this outcome by learning to adapt the regulations to our special situations.

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SECTION II: ISSUES AND PROBLEMS

The rapid increase in concern for animal rights and welfare and the resulting increase in regulations and regulatory committees and agencies has lead to a number of issues and difficulties that must be addressed. This Section discusses some of these problems.

As was pointed out in the last paper in Section I, meeting U.S. regulations for animal care and use can be very difficult for small institutions, especially those that are not located in urban areas. It may be difficult to locate a qualified veterinarian or a community representative for the IACUC or to establish an occupational health program for persons working with animals. Such institutions do not often have outside funding to allow renovation of antiquated animal housing facilities or the building of new ones. Current regulations can cause severe problems for these institutions. Jack Demarest has conducted a survey investigating the impact of U.S. regulations on small colleges, finding that many are not in compliance and that some have even eliminated animal use from their institutions.

It is also apparent in reading the regulations on animal use that they were written with biomedical laboratory research in mind. It is sometimes difficult to see how they apply in other areas. To help with this problem, researchers in some areas have developed their own guidelines. In this section, Gail Michener discusses ethical animal use in field work, including new guidelines for field research developed by several professional groups of scientists. She also discusses the importance of basic research and the need to explain its value to the public.

Although there is some public concern about the use of animals in agriculture, at the present time agricultural animals are exempt from the provisions of the Animal Welfare Act. In his paper, Ray Stricklin discusses some current agricultural practices and describes the development of new guidelines for the use of agricultural animals in research and teaching.

Regulations of animal care and use were written with vertebrate animals in mind. The term "warm-blooded" was used for some time until its ambiguity was finally explained to law makers. In the United States, the NIH regulations apply only to vertebrate animals and the Animal Welfare Act, at the present time, applies only to a very limited number of vertebrate animals. In her paper, Jennifer Mather points out that limiting our concern for humane use of animals to vertebrates is based on the mistaken notion that mammals, especially humans, represent the apex of evolution. She shows that there are a number of different evolutionary paths leading to animals with complex nervous systems, complex behavior and perhaps intelligence and self-awareness and argues that it is inconsistent to ignore many animals simply because their nervous systems are not organized in the same way as ours.

GHETTOIZING ANIMAL RESEARCH:

THE IMPACT OF FEDERAL REGULATIONS ON SCIENCE AND EDUCATION IN SMALL COLLEGES

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The Animal Welfare Act as amended in 1986 (P.L. 94-279) and the Health Research Extension Act of 1985 (P.L. 99-158) have produced a number of scientific meetings to discuss the rules and their impact upon education and research. The participants at these meetings have generally represented major universities and research institutions in the United States. I've come away from these meetings with the conviction that neither I nor most of my colleagues at small colleges could comply with the regulations, or afford the mandated alterations in the facilities, staffing and maintenance of our laboratories. It has also become apparent that many of the participants interpret the laws differently. In the spring of 1988, I conducted a survey of small colleges on how the Animal Welfare Act and the Health Research Extension Act were affecting science and education, particularly in the behavioral sciences. This report is a summary of the results of that survey and what I think these data mean.

METHODS

Sample Population

Surveys were sent to animal researchers at 100 small colleges in the United States. For this study, a "small college" was defined as a four year institution with an enrollment of less than 7,000 students, based upon the enrollment figures listed at the back of the *American Heritage Dictionary* (Morris 1982). One exception that I made was that major research institutions such as Princeton with undergraduate enrollments of less than 7000 were not included. Using the 400 member subscription list of the *Comparative Psychology Newsletter*, I was able to identify 76 animal researchers affiliated with small colleges. Another twenty-four small colleges were selected at random from the college listing in the *American Heritage Dictionary*, with the stipulation that no college could be represented more than once in the survey. Most of the surveys were sent to psychology departments.

Survey Instrument

The survey questionnaire consisted of 43 questions divided into seven sections. There were two questions on general

information, eight questions pertaining to Animal Care and Use Committee regulations, and fifteen questions that had to do with facilities and/or procedures regarding housing, feeding, watering, exercising, sanitation, ventilation, and so forth, as specified in the Animal Welfare Act. Six questions had to do with financial issues; four questions pertained to the support of administrators, faculty colleagues and students for animal research; four questions had to do with the impact of the regulations on research activities; and four questions had to do with the impact on teaching and education. A one page check list was provided for answers with options "Yes", "No", "Don't know", and "Doesn't apply", for most of the questions. There was also room for additional comments. A cover sheet indicated why this survey was being done and asked for responses to all questions. A stamped, self-addressed return envelope was provided, and the cover letter assured the participants that all responses would be anonymous.

RESULTS

There was a 43 percent return rate of the questionnaires which is typical for surveys of this type (Demarest 1980). Two of the 43 returns were left blank and attached to a letter. One of these indicated that her institution no longer maintained live animals and the second indicated that enrollment at his college was over 7,000. The remaining schools on the list fit the criteria for a small college. Two respondents indicated that their institutions also had eliminated live animals from teaching and research. However, because they completed the survey, their data are included. The following summary is based on a total of 41 responses.

The first substantive question was "Do you feel that the Animal Welfare Act and Health Research Extension Act discriminate unfairly against small college science programs?" Over 50 percent of the respondents answered that the federal regulations do discriminate against small college science programs, while less than 30 percent of the respondents answered that the federal regulations do not discriminate against small college science programs. Here are two typical comments:

(1) Our facility is clearly not in compliance and funds are simply not available for support personnel (e.g., DVM, full-time personnel). We are requesting lab renovation but it is unlikely that staff support will be provided. If strict enforcement comes, I suspect that we will be out of business...I believe that the potential for serious bias against small campuses (especially remote ones) is clearly a part of the regulations.

(2) It seems I spend more time meeting regulations and doing paperwork than I spend on providing opportunities for our students to do observations and experiments..... Films, though useful, are no substitute for actually working with the animals. I appreciate what the new regulations are trying to accomplish, but it appears to be overkill for the kind of work I and several of my colleagues do, rather did.

To get a better idea of whether or not the respondents have, in fact, complied with the legislation, a series of questions about specific regulations was included. However, I first asked if they knew what the regulations were. Almost 90 percent of the respondents answered Yes to this question. Also, 85 percent indicated that they had an Animal Care and Use Committee (ACUC) in place. While most of the institutions in this survey have complied with the basic regulations of forming a committee, and most have become familiar with the rules, many respondents had comments to offer about problems they've encountered in trying to work within these rules. For example:

(1) Protocols for laboratory exercises and/or research have been rejected by the ACUC based upon issues of scientific merit by individuals who are unqualified to make these decisions. As a result, some of our research and coursework has been terminated, and other research is continuing without the approval of the ACUC.

(2) Small colleges, often located in small towns, may not have the required constituents of ACUCs for placement on such a committee due to the absence or disinterest of qualified individuals...Additionally, if members are to be compensated for the extensive demands on their time, the small college is again at a disadvantage.

(3) When teaching rather than funded research is the total activity of the small college and when short-term student projects are the focus, the use of an ACUC simply is not feasible. The small college must then stop using any live animals in teaching or knowingly violate the law.

Animal Care and Use Committee Regulations

For the purpose of this discussion, the first series of questions regarding specific regulations are grouped together in terms of whether they refer to personnel and administrative procedures, or facilities and maintenance procedures. The Animal Welfare Act requires veterinary care by a specialist in laboratory animal medicine. When asked whether their institution required such specialized veterinary care, better than 42 percent replied No. When asked if a DVM was consulted in the planning of all research involving surgery, 38 percent of the respondents said no. More interesting still is the answer to the question "Does a veterinarian or other qualified individual observe all laboratory animals daily to assess their health and welfare"? Sixty-eight percent of the respondents answered No to this question. Thus, while 85 percent of these schools have an ACUC, only about 50-60 percent involve a veterinarian, and the regulations pertaining to the veterinarian's responsibilities are being complied with by only one-third of the small colleges responding.

The Animal Welfare Act also mandates training for animal technical personnel in animal care procedures and animal husbandry procedures. When asked whether their institution requires such mandatory training for animal technical personnel, more than 43 percent of those responding indicated that there was

no training in animal care, and 60 percent indicated that there was no training in animal husbandry. Another 10 percent of the respondents to these questions indicated that they did not know, and I suspect that the number of institutions violating this regulation is even higher.

Another reguirement of the Animal Welfare Act is that each institution should implement an occupational health program in which administrators and technical personnel would be alerted to the health problems of working with specific animals and provided guidelines for dealing with these dangers. Nearly 60 percent of the respondents indicated that there was no such program at their institution. Seventy-three percent of the sample did not have a full time animal caretaker despite the specific regulations, and of those who did only three of them were certified by an accredited organization, another of the regulations in the Animal Welfare Act.

Thus far, the survey shows that most small colleges do have Animal Care and Use Committees, but that the institutions are not complying with at least some of the regulations pertaining to hiring and training of personnel associated with animal husbandry, care and research. Other questions also indicated that the ACUC was not meeting its requirements pertaining to reports and record keeping. Better than 42 percent of the respondents indicated that their institution was not requiring reports every six months on the animal program facilities and/or personnel training. Moreover, only about 50 percent of the respondents indicated that they had an approved or provisionally acceptable Animal Welfare Assurance form on file with the Public Health Service, Office for Protection from Research Risks. The general impression one gets from the comments was that the sheer amount of work involved in keeping daily records and writing the semi-annual reports makes this regulation unreasonable for most small college faculty, unless an additional administrator can be hired.

Facilities and Procedures for Maintaining Animals

Another series of questions had to do with facilities and maintenance procedures. The Animal Welfare Act identifies standards for housing, feeding, watering, exercising, sanitation and so forth. These standards are often very specific, and seemed designed primarily for university settings or large research institutions. For example, one of the questions asks "Do your facilities permit housing different species in separate rooms"? Most respondents (73 percent) answered that their institution did meet these requirements. A smaller number (65 percent of the respondents) indicated that their facility had designated restricted areas for storage of bulk food and a separate area for sanitizing cages and equipment. However, this was not the case in a third of the colleges responding. The Animal Welfare Act also mandates that the facilities include a procedure for quarantine of newly received animals. Fifty-eight percent of the institutions responding indicated that they did

not meet this requirement. An even larger percentage (66 percent) indicated that their institution did not provide separate aseptic surgery rooms intended solely for this purpose. Questions relating to humidity standards or ventilation standards were typically answered in the positive, although a large percentage of people simply did not know if their institution met those requirements. The regulations also require washing of cages and cage racks at least twice a month, a mandate violated by over 50 percent of the institutions responding. Perhaps the most controversial regulation is the provision for supplementary or induced activity as a means of exercising laboratory animals. When asked about this, 93 percent of the respondents indicated that they did not meet this requirement.

Financial Issues

The next part of the survey had to do with financial issues. In this section, I was interested in whether or not small colleges could satisfy the provisions of the Animal Welfare Act without major funding for renovations. The first question was "Can your institution conform to these regulations without major funding by federal, state, or private grants"? A plurality of the respondents (45 percent) answered No to this question, and another 20 percent said that they didn't know. Over 70 percent of the respondents indicated that their college would attempt to comply with the federal regulations anyway. The survey also asked, "Have you had to renovate your animal facilities to meet these requirements"? Fifty-six percent of the respondents indicated that they had. The median estimated cost of renovations was $20,000, with a minimum estimate of $5,000 and a maximum estimate of 1.75 million. Respondents were also asked to indicate how the renovations done on their facilities had been financed. The overwhelming majority of institutions support renovations through college funds, either alone or in combination with federal or private monies. Half of those responding indicated that funding for facilities and staff had been a problem in complying with the Animal Welfare Act.

Research Activities

Another series of questions were designed to determine the impact that these regulations have had on research activities. One question asked was, "Has the mandate that grantees comply with the NIH or USDA regulations been a deterrent to applying for federal or state research grants to do animal research?" Of those responding, 56 percent indicated that the regulations had not been a deterrent. However, 32 percent indicated that the regulations did discourage them from applying for grants. Asked whether the regulations would significantly affect the kinds of faculty research done at their institution, 51 percent indicated that it would. When asked whether the regulations had prevented the respondent, his or her colleagues, or students from doing certain types of research, 44 percent indicated that it had. Thus, for this sample of researchers, at least, the provisions of the Animal Welfare Act have had a

negative impact upon animal behavior research. Moreover, only 24 percent of the respondents had the opinion that the regulations would improve the quality of research done with animals at their institution. Another 20 percent did not know or were unsure, and 54 percent of the respondents indicated that there would be no improvement in the quality of research done with animals at their institution. Thus, the vast majority of individuals have not seen any improvement in the quality of the research done under the auspices of the Animal Welfare Act, and most have had to alter the kinds of research that they were doing. Some scientists have even stopped doing animal research and this is precisely what lobbyists for the animal rights movement have been trying to accomplish all along (McCabe 1986; Pincus, Fine, Pardes & Goodwin 1986; Holden 1987).

Attitudes About Animal Research and Its Impact on Education

An important aspect of the impact of the Animal Welfare Act is how it has affected attitudes about animal behavior research. Most people indicated that the regulations had not affected the attitudes of students, faculty or administrators at their institution. However, of those who said they did, most indicated that there was less support for animal research now than before. It was also revealed that most schools (92 percent) provided their students with opportunities for direct experience working with animals. When asked whether the federal regulations seriously affected the opportunities these students had to study animals, most of the institutions (66 percent) indicated that they had no impact, although 33 percent thought that there had been a negative effect upon undergraduate majors.

SUMMARY

The use of animals in science continues to be the subject of increased public attention. Most of the meaningful debate has focused on what constitutes an appropriate animal care program, with the answers typically reflecting a particular philosophy rather than an empirically based argument (e.g., Landers 1987). The most common problem has been a lack of funds to support the facilities and staff mandated by law, and the most common criticism has been that the regulations are unnecessary and unreasonable. In this survey, few respondents said that the regulations have improved or will improve science education or the quality of research done with animals at their institution and a large minority actually thought the rules have had or will have a negative impact. Several colleges have closed their animal labs and most are operating in violation of some aspect of the law. Those that are not have diverted college funds from educational programs to support the renovation of animal facilities. In some cases the threat of monetary penalties has inhibited college administrators from promoting these science programs even when they recognize their importance. This not only means a lack of support for renovations of animal facilities, but also less space and staff support for animal

researchers, fewer faculty lines for animal scientists, and a lower likelihood that these faculty will get tenure and promotion. One individual even complained that his state university seemed to be using the issue as an excuse to monopolize research scientists and grant funds at the university centers, depriving the smaller colleges in the system of faculty and resources.

It is important to recognize that much of the reaction of government and the academic sector has focused on the pressures brought to bear on the scientific community at major universities and research institutes. The unique problems of small colleges have been overlooked in this process. This survey shows that institutions strapped economically and without the requisite physical space for renovations are unable to comply with the laws regulating animal facilities. The net effect has been to isolate most small college science programs. We become less competitive in recruiting faculty and grant money and we must either violate the law or eliminate live animals from our research and academic training. If the regulations continue to have a negative impact, students from most small colleges will not be provided the same opportunities for training and research that larger institutions can provide. The result will be the ghettoization of animal science education.

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ETHICAL ISSUES IN THE USE OF WILD ANIMALS IN BEHAVIORAL AND ECOLOGICAL STUDIES

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Until the mid 1980s, guidelines outlining the care and use of experimental animals in North America were formulated primarily with regard to the small number of laboratory and livestock species used in biomedical, pharmaceutical, agricultural and veterinary research. Because research in these areas is primarily focussed, directly or indirectly, on health issues pertaining to humans and their domesticated species, the underlying ethic in justifying the use of animals is that "there must be reasonable expectation that such studies will contribute significantly to knowledge which may eventually lead to the improvement of the health and welfare of either man or animals" (CCAC 1980). This expectation enables a proportionality test to be applied to such research with the benefits to society being weighed against the costs to the animals. Baker (1987, p. 32) noted that "It is widely accepted that certain procedures which may cause pain or discomfort may be .... acceptable if the balance of analysis clearly favors societal benefit over ethical costs." Orlans (1987a, p. 51) echoes this sentiment by stating that institutional animal care committees "must ask the fundamental question of whether the proposed experiment furthers the public good" because some experiments "can only be justified if the social good derived .... outweighs the negative aspects of harming a sentient creature." Such statements are anthropocentric in that they indicate that a certain amount of suffering by animals is acceptable provided humans and their companion or food species benefit. Although not explicitly stated, inherent in such justifications is the notion of animals as expendable tools to be consumed by experimenters if the research goals warrant. The animals are the means by which the research goals can be achieved and as such are secondary to those goals. Lacking from ethics and proportionality statements formulated with a biomedical perspective is recognition of the merit of studying animals for the sake of understanding the animals themselves.

The ethic that human society must benefit overtly from research, although appealing and readily understood by the general public, does not apply to the majority of studies of wild animals by zoologists because pure, basic research does not have human health and welfare as its goal. The diversity of species and concepts that have attracted scientific attention and funding by national granting agencies can be quickly appreciated by scanning the table of contents of zoological journals such as

Animal Behaviour, *Behavioral Ecology and Sociobiology*, the *Canadian Journal of Zoology*, the *Auk*, the *Journal of Mammalogy*, the *Journal of Herpetology*, *Copeia*, *Physiological Zoology* and many others. Most zoologists publishing in such journals would consider themselves to be hypocrites if they claimed their research was likely to benefit humans in the commonly accepted sense of the term. The Canadian Council on Animal Care, a supervisory and advisory agency founded in 1968 (Michener, this volume), was among the first organizations concerned with animal welfare to acknowledge explicitly that zoologists often have research goals that differ from those of the applied branches of life sciences. In 1980 the CCAC formed a committee to address issues in the use of wild vertebrates, with the result that Vol. 2 of the CCAC Guide (1984) states that "A return of knowledge and understanding applicable to the species under study constitutes a major justification for their use." Throughout the 1980s, professional societies of field biologists formulated guidelines that focus on the use of wild species in zoological research, set professional standards for use of wild animals and recognized the value of basic research (see Appendix). The Animal Behavior Society set the tone by including in its guidelines published in *Animal Behaviour* (1986 p. 315) the statement that "the furthering of scientific knowledge is a proper aim". The ornithological, herpetological, and ichthyological societies published parallel guides in 1987 and 1988, each of which includes the statement that "the acquisition of new knowledge and understanding constitutes a major justification for any investigation." The American Society of Mammalogists expresses the same sentiment in their 1987 guide in the statement "Field investigations ...enhance our understanding of the complexities of mammalian relationships in time, space, within and among species, and with other components of the biotic and abiotic environment." Thus the emphasis in zoological research is on understanding the individual, population, species, or community, not because humans may benefit overtly but because any extant species merits attention and because the pursuit of knowledge about the natural world is itself a laudable goal.

The acquisition of knowledge does not justify unethical or inhumane treatment of animals, and a proportionality test still applies in judging the wisdom of using a particular procedure or protocol for wild species and field studies. The guidelines of the Animal Behavior Society (1986 p. 316) emphasize that "investigators should weigh any potential gain in knowledge against the adverse consequences of disruption for the animals used as subjects and also for other animals and plants in the ecosystem." This injunction places different responsibilities on the field biologist working with free-living animals than on the biomedical researcher working with captive, domesticated animals because the former must review the consequences of field work on the entire ecosystem whereas the latter usually need only address the consequences of laboratory work on the subjects themselves. Although the concept of balancing scientific goals with ethical costs applies both to field and captive studies, the value given to the animal differs in a subtle but real way.

Because knowledge about the animals themselves is frequently the goal of field studies, the animals appear on both the cost and benefit sides of the equation. Furthermore, the biasing effect of a presumed benefit to humans is absent in field studies so the real costs to the animals are likely to be more fairly assessed. Difficult ethical decisions can still remain such as when working with rare or endangered species or on projects concerned with conservation and management that require the field worker to determine whether the life or freedom of an individual must be sacrificed to save the population or species as a whole.

The public tends to have two rather simplified views of study animals: the laboratory species living at the mercy of scalpel-wielding scientists in lab coats and the field species living a romanticized life of freedom as seen through the lens of the wildlife photographer. The latter perspective renders field biologists free of much criticism from an animal welfare perspective when the study involves only simple observation with no greater disturbance than brief live-capture of individuals to place identifying marks on them. However, when some manipulation is involved, such as laparotomy to assess sex in monomorphic species of birds or removal of the dominant individual to determine how the vacancy is filled, the study is more obviously experimental in nature and more likely to be judged by the criteria that are applied to biomedical research. If a proportionality test is applied with societal benefit being placed on one side of the scale and if societal benefit in a field study is judged to be nil because the health and welfare of humans or their pets and livestock are not research goals, then even modest manipulations with low levels of invasiveness can be judged as having too high an ethical cost.

Assessment of the value of manipulative work with field species is an area in which the different ethics held by researchers conducting pure versus applied research, with their different justifications for research, become apparent. Biases in the basis for judging scientific merit can overwhelm the issue of humane use of animals. One of the example case studies of ethical dilemmas presented by the Scientists Center for Animal Welfare (SCAW) (Orlans 1987b, p. 63) at a workshop on the functioning of animal care committees concerned a study of social status in a species of lizard in which tail autotomy occurs naturally. The relative dominance of lizards that experienced different amounts of tail loss was to be assessed in paired encounters to determine the role of total body length in achieving and maintaining dominance rank. For each case study, pertinent questions in need of discussion were provided. For this study, the first question began with the preamble "The purpose of this study appears to be the acquisition of zoological knowledge, the results having no apparent practical application that would benefit either humans or animals" thereby prejudging the scientific merit to be zero because the study had no applied goals. No questions were posed as to how experimenters planned to induce tail breakage, how quickly tails regrow, whether the reaction of lizards following natural autotomy in the field

suggests they feel discomfort, or whether neuroanatomy of the lizard suggests that pain would result from tail loss. Instead the first question addressed the merit of pure research and the second queried the limits of replicating injuries in the lab, but made no distinction between a natural predator-evasion mechanism such as tail autotomy that enhances survival and an accidental event such as leg or wing breakage that may seriously limit mobility. Thus, the questions reflected a misunderstanding of the phenomenon under study with the consequence that relevant animal welfare questions were not posed. As another example, I submitted a case history for use at one of the SCAW workshops with the title "Infanticidal behavior of male house mice". This was altered to "Staged Cannibalism", a provocative and erroneous title that misrepresented the purpose of the proposed experiment. Studies of infanticide raise serious ethical questions, as is indicated by the statements included by authors of such studies (e.g. Soroker & Terkel 1988, p.1277), but such questions need to be discussed in an atmosphere of understanding the purpose of the study. Field biologists must take an active role in educating their colleagues in the more applied branches of life sciences to the importance of addressing the ethical and welfare issues with an open mind rather than prejudging basic zoological research as worthless.

Animal care committees must be wary of applying anthropocentric standards to zoological research when addressing pertinent welfare issues in protocols involving field species. The field guidelines published by professional societies that work with vertebrate groups provide guidance to animal care committees on the purpose of studies of wild species, indicate the professional standards accepted for that taxonomic group, emphasizing intertaxon variation in behavior and physiology that renders a technique acceptable for one species but inappropriate for another, and encourage appointment of a field biologist to the committee. SCAW has taken an active role in alerting animal care committees to the existence of these guides through a workshop and resultant publication that highlights fundamental differences between field and laboratory investigations (Orlans, 1988). Thus, recognition of the different goals of zoological and medical research is now coming from other branches of the life sciences.

Field trapped animals are sometimes brought into captivity, raising the question of suitable housing and caging. The CCAC (1984), the professional societies of field biologists (Appendix), and SCAW (Orlans 1988) emphasize that conditions suitable for maintaining domesticated species are often unsuitable for wild species. Because of the enormous number of species even within one taxonomic group (e.g., in excess of 9000 species of birds) and because the behavioral, ecological, and physiological characteristics of most species are poorly known, the professional societies can only provide general information on suitable captive conditions. Often animal care committees must depend on the experience, wisdom, and sensitivity of the field researcher who is familiar with a given species in the wild

rather than on the veterinarian or laboratory animal scientist whose expertise is limited to the handful of species commonly maintained in captivity (see Orlans 1988 p.18).

Axiomatic for both field and laboratory studies is the concept that the welfare and well-being of subjects is of paramount importance for both ethical and scientific reasons because traumatized animals will not yield useful behavioral or physiological data. Only when the goal of the project is to understand the consequences of a particular trauma can this concept be violated and such violation is more likely to be necessary in biomedical research than in field research. Generally, the captive research animal lives in an environment free from risks such as predation, parasitism, poor food supply and exposure to inclement weather. However, the captive research animal lives a life entirely controlled by the investigator and animal care technician. Its birth and death are dictated by the experimenter who decides when to breed or procure the animals needed for an experiment and decides when to kill the animals, either as an integral part of the experimental protocol or before the animal becomes decrepit from old age. The laboratory animal thus is often a research tool that, like sophisticated equipment, requires special care and attention but ultimately is expendable and replaceable. The more easily and cheaply a species can be bred in captivity, the more likely is it to be used in short-term experiments with high turn-over rates. Field ecologists and behaviorists typically view their research animals as irreplaceable, non-expendable items. Observer-induced mortality is antithetical to the goals of most behavioral and ecological studies. For both ethical and scientific reasons the researcher wants each animal to live out its natural lifespan, though this may be short due to natural events such as predation and starvation, and will forego data collection rather than expose animals to risk or disturbance.

All field researchers and all animal care committee members that review field protocols should be familiar with the guidelines published for birds, mammals, reptiles, amphibians, and fishes (Appendix). To date, invertebrates are covered by few guides (see Mather, this volume) but the Canadian Council on Animal Care does require submission of protocols for invasive studies on those invertebrates with relatively complex nervous systems such as cephalopods. The set of guides published by the professional societies for the vertebrate groups can be purchased for US$5 from SCAW, 4805 St. Elmo Ave., Bethesda, MD 20814, USA and Volume 2 of the CCAC guide which includes a chapter on wild vertebrates can be purchased for CDN$6 plus postage from CCAC, 151 Slater St. Ottawa, Ontario, Canada K1P 5H3.

SUMMARY

The scientific societies representing field biologists who study fish, amphibians, reptiles, birds, and mammals published guidelines in 1987 and 1988 (see Appendix) outlining

professional standards for the use and care of wild species. These guides, along with guidelines published by the Animal Behavior Society and the Canadian Council on Animal Care, emphasize that the purpose of most research with field species is acquisition of knowledge about animals and their environment. Thus, proportionality tests that weigh the costs to animals involved in research against the benefits of the research are formulated differently from those applied to biomedical research. Animal care committees should be aware of the fundamental differences in the goals of basic versus applied research when they address the ethical issues pertinent to a research protocol.

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APPENDIX: Some Guidelines for Field Research

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THE DEVELOPMENT OF GUIDELINES FOR THE CARE AND USE OF AGRICULTURAL ANIMALS USED IN AGRICULTURAL RESEARCH AND TEACHING

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The first edition of the *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* was published in March 1988. It was developed by and for persons who use agricultural animals for the purposes of 1) teaching current agricultural practices and 2) researching improved and alternative animal agricultural production practices. The *Agricultural Animal Guidelines* are meant to serve as an independent reference for the care and use of agricultural animals, just as the National Institutes of Health *Guide for the Care and Use of Laboratory Animals* (1985) has served users of animals in biomedical research and teaching since the first edition was published in 1963.

The *Agricultural Animal Guidelines* provide information on the most common agricultural animals under a variety of teaching and research circumstances, including some of the more common animal production systems in different parts of the United States. The *Agricultural Animal Guidelines* were not, however, intended to establish standards for privately owned farm animals, just as the NIH *Guide* does not establish housing and welfare standards for the dogs and cats of pet owners. Specifically, the objective of the Consortium that developed the *Agricultural Animal Guidelines* was to establish a document that outlined housing, management, and care standards for animals used in agricultural teaching and research activities. To understand the basis for developing *Agricultural Animal Guidelines*, one must understand some of the background and history and the current practices of animal agriculture in the United States. This presentation will follow such a format.

BACKGROUND AND HISTORY

One hundred years ago, North America was predominantly a rural, agricultural society. The typical American grew up on a farm and learned by experience that the family food supply was the product of long hours of tedious and strenuous human labor. People of that time knew as children that the quantity and quality of their food were dependent upon the cycles of the seasons, weather, pestilence, disease, animal pests and

predators, and other "forces" of nature. The well-being and existence of the family was viewed as a struggle against nature. The killing of animals, both those for food and those that were threats to the food supply, was accepted as necessary for human survival.

Members of the American public today have an image of animal agriculture based more often on folklore than on fact. Some persons tend to think about agriculture in terms of the so-called "family farm". Many of us grew up on farms or our grandparents lived on farms and some of us may think of the farm as a sanctuary for animals or even a human sanctuary; a place to go on Thanksgiving and Christmas holidays. In story books, the farm is a place where cows graze contentedly with horses and sheep, where dogs and cats and chickens live happily together in the farmyard, and where human life is simple, restful and peaceful. But in fact the stereotyped storybook "family farm" does not exist today as a viable economic unit in American society except for persons like the Amish who choose to raise livestock and lead an austere lifestyle.

Today in the United States less than 2% of the population live on farms that are active in animal-based food production. The other 98% of the general public develop their attitudes toward animals primarily from their interaction with pets and from media avenues such as television and newspaper cartoons. As a result the attitudes developed by children about animals and about the give and take of life and death within nature are different from those one might hope to have among students properly educated about biology or animal science.

CURRENT ANIMAL AGRICULTURAL PRODUCTION SYSTEMS

Current agricultural practices relative to farm animal well-being have been reviewed numerous times (CAST 1981; Curtis 1986; Mench & van Tienhoven 1986) and considerable coverage in the popular press is given to the topic. However, in general there is still a significant information gap not only between producers and consumers, but also between the life scientists and the applied biological scientists in agriculture. Much of this knowledge gap involves a basic lack of awareness of current agricultural practices. Even those persons aware of such practices are too frequently lacking in knowledge about the history associated with the development of current practices and the reasons why they are being employed.

A dairy farm today may not be recognizable by the majority of the public. An increasing amount of milk is being produced by multiple-thousand head dairy operations which from a distance resemble large beef feedlots. Typical swine, veal, and poultry barns have few visual cues that identify them as animal barns except possibly the feed bin often standing outside the building.

Inside confinement farm buildings animals often reside in various types of structures that restrict their movement. Laying hens live in wire cages, sows in confinement pens or stalls, and veal calves in individual confinement crates. In some laying hen buildings, groups of four to six birds are kept in cages of a size approximately equivalent to the body dimensions of the birds, and as a result the movements of the birds are restricted.

Sows are often housed in straight, narrow stalls or tethered by a neck chain or strap around the withers, behind the front legs, in such a manner that they are unable to turn around. Some sows are maintained year-round in this manner. More typically, sows are placed in farrowing crates several days before farrowing and kept there for 3 to 4 weeks, until the piglets are weaned.

Animals are also maintained in very large groups in some production situations. Beef feedlots sometimes contain groups with over a thousand head of steers or heifers in each pen. In broiler production houses (poultry raised for meat production), as many as ten thousand chicks are open-housed together, on a deep-litter floor, as a single group from 2 to 3 days after hatching until the birds are slaughtered at approximately 6 weeks of age.

The large group sizes and crowding sometimes causes increased fighting and other agonistic behaviors among group members. The teeth, beaks, horns and claws of farm animals are responsible for some of the major bodily injuries to group mates. To minimize these adverse effects, animals are often "altered". The upper front part of the beak is removed from laying hens when they are chicks to prevent pecking of cage mates later in life. Claws are removed from breeding roosters and some laying hens to prevent injury to the backs of hens. The horns are removed from calves to prevent bruising and injury to pen mates and to humans by adult cattle. Castration is used to decrease the level of aggression within pens of older male cattle and swine.

The confinement of livestock in systems such as those described above have been criticized by several persons (Harrison 1964; Singer 1975; Mickley & Fox 1986). The positions of the persons opposed to intensive confinement of livestock, sometimes called "factory farming", are varied but include contentions that animal agriculture 1) is based on strictly economic considerations and that its exploitation of animals for profit is unethical, 2) is biologically inefficient because it consumes more energy and protein than it produces, 3) produces animal food products that are harmful to human health, 4) is harmful to the environment because of overgrazing, nitrate runoff into surface water and build-up in ground water, 5) is too dependent on use of growth promotants and antibiotics, 6) is moving toward possible manipulation of the DNA of animals, and 7) is harmful to the well-being of animals because of the behavioral deprivation animals experience in intensive confinement practices. There is of course some basis for each of these points raised. However,

the complexities of these issues are too frequently ignored in favor of a condemnation directed toward all animal agriculture. Discussion of, or rebuttals to, each of the points mentioned above have been reviewed by several authors (CAST 1981; Acker 1986; Curtis 1986; Stricklin 1989). Anti-animal agriculturalists and pro-animal agriculturalists have too often engaged in "trench warfare" with each side making accusations about the philosophy, tactics, methodology and actions of the other. There has been too little successful dialogue.

There has been a tendency for polarization of individuals into two positions. The positions of the animal welfare and animal rights persons are wide-ranging as stated above. The animal producers, on the other hand, contend that as husbandmen of animals, they have the best interests of animals at heart. In addition, they are fulfilling their societal obligation of providing cheap food and feeding the hungry people of the world.

Table 1

Improvements in Efficiency of Producing Foods of Animal Origin between 1925 and 1975.

Species and measures of values	Productivity in indicated years		
	1920	1950	1975
Beef cattle			
Liveweight marketed per breeding male (pounds)	220	310	482
Sheep			
Liveweight marketed per breeding female (pounds)	60	90	130
Dairy cattle			
Milk marketed per breeding female (pounds)	4,189	5,313	10,500
Swine			
Liveweight marketed per breeding female (pounds)	1,600	2,430	2,850
Broiler chickens			
Age to market weight (weeks)	15.0	12.0	7.5
Feed per pound of gain (pounds)	4.0	3.3	2.1
Liveweight at marketing (pounds)	2.8	3.1	3.8
Laying hens			
Eggs per hen per year (number)	112	174	232
Feed per dozen eggs (pounds)	8.0	5.8	4.2

(After CAST, 1981)

Because of intensive confinement animal agricultural practices, agricultural animals of today are faster growing, have higher reproductive efficiency, and are better at converting feed to weight gain than were animals of 50 or even 25 years ago (Table 1). A major justification, or at least reason, for animal agriculture moving toward confinement-type situations is to produce less expensive food. In America we have a federal policy of producing food cheaply and in surplus. We as consumers spend less than 15% of our income on food, which is approximately one-half the amount that Europeans spend. Intensive housing systems, which have consequences with regards to the amount of freedom of movement allowed to animals, have helped reduce labor costs and improve the efficiency of production. Thus, the major beneficiaries of intensive animal housing are the consumers.

GUIDELINES FOR AGRICULTURAL ANIMALS

The background information above indicates that there is a general public concern for animal well-being including that of both farm animals and animals used in research. Animal care and use guidelines for non-agricultural animal-based research financially supported by the Public Health Service have been covered within these proceedings by Stephens (this volume). However, in the past, agricultural animals used in research and teaching have not been subjected to review by an Institutional Animal Care and Use Committee (IACUC).

A group of organizations and agencies decided in May 1986 to develop the *Agricultural Animal Guidelines* (Curtis, 1989). They established the Consortium for Developing a Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. Each member group was represented on the Consortium's Coordinating Committee which also included a representative of the public. At a meeting in July 1986, members of an Executive Committee were elected and the Guide Development Committee and six Guide Development Subcommittees were planned.

The Guide Development Subcommittees included ones for beef cattle, dairy cattle and veal calves, horses, poultry, sheep and goats, and swine. Each of these sub-committees was composed of three or four animal scientists, one veterinarian, one agricultural engineer and a representative from industry. The chairperson of each of these committees was a person with experience in applied animal behavior studies. Each Subcommittee Chairman had also participated in activities in the North Central Regional-131 Committee on Animal Care and Behavior, a committee of government and university agricultural researchers and educators. Irvin Omtvedt, University of Nebraska, chaired the Consortium Executive Committee and Stanley Curtis, University of Illinois, was chairman of the Guide Development Committee. The *Agricultural Animal Guidelines* was completed on time and under budget, much to the credit of Drs. Omtvedt and Curtis.

The contents of the *Agricultural Animal Guidelines* included information about institutional policies, general guidelines for animal husbandry and health care, physical plant, and husbandry guidelines for beef, dairy, horses, poultry, sheep and goats, swine, and veal. The procedure for establishing an agricultural animal care and use program is outlined in the institutional policies chapter, which states that the program should be managed in accordance with the *Agricultural Animal Guidelines* and in compliance with applicable laws, regulations, and policies. The appropriate administrative official at each institution should appoint the institutional agricultural animal care and use committee. The committee may be the same committee that is responsible for monitoring and overseeing the institution's laboratory animal care and use program (Mench, this volume) provided the special membership requirements for the care and use of agricultural animals are fulfilled as outlined in the *Agricultural Animals Guidelines*. The committee should include:

1) a scientist from the institution with experience in agricultural research or teaching involving agricultural animals,

2) an animal scientist who has appropriate training and experience in the management of agricultural animals and with recognized high professional credentials as verified by the scientific and professional societies in animal science, dairy science, or poultry science,

3) a veterinarian who has appropriate training and experience in agricultural animal medicine and who is appropriately licensed or eligible to be licensed to practice veterinary medicine,

4) a person not otherwise affiliated with the institution, and

5) other members as may be required by institutional needs and applicable laws, regulations, and policies.

The committee should be responsible for approving and monitoring the institution's agricultural animal care and use program as well as facilitating and supporting agricultural animal care and use. The committee should:

1) meet at regular intervals to ensure that the use of agricultural animals in teaching and researching programs is humane, appropriate, and in accordance with the *Agricultural Animal Guidelines*,

2) review protocols for animal care and use in research and instruction,

3) at least twice per year, conduct an inspection of the physical facilities, review the overall agricultural animal care and use program, and provide a written report to the responsible administrative official of the institution's compliance with the *Agricultural Animal Guidelines*, and

4) perform other functions as may be required by institutional needs and by applicable laws, regulations and policies.

The *Agricultural Animal Guidelines* are intended to establish standards for persons using animals in agricultural teaching and research activities. To accomplish these goals, the researchers and teachers must use facilities and production systems that are currently being used by the animal agricultural industry.

SUMMARY

In the recent past, the majority of research institutions' agricultural animals have been excluded from the review of the IACUC, and for those which did review agricultural animals, there was no standard document outlining appropriate guidelines. Because of increasing concern about the importance of including agricultural animals in institutional animal care and use programs, a consortium of scientific and professional organizations, industrial groups and governmental agencies was formed to develop agricultural guidelines. From their activities, a *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* was published in March 1988. The development and writing of these guidelines occurred in conjunction with a series of Consortium committee and sub-committee meetings held during 1987 with successive drafts reviewed for comments by an increasingly larger group of interested persons. The initial draft of the *Agricultural Animal Guidelines* was developed from input by six Guide Development Subcommittees representing the major farm animal species-types with each of these Subcommittees chaired by an animal scientist who had a background and experience in applied ethology. Also, each of the Subcommittees included a veterinarian, an agricultural engineer, an industry representative, and an animal science researcher or educator. Through the review process, the information compiled by the six species-based Guide Development Subcommittees was condensed into a 74 page document by a seven-person writing committee. Because agricultural research and teaching are oriented toward serving an important economic base, the farming community, the current practices and issues in animal agriculture were an important consideration when writing the *Agricultural Animal Guidelines*.

NOTES

1. Published as Scientific Article No. A-4894, Contribution No 7932, of the Maryland Agricultural Experiment Station.

2. Portions of this manuscript include direct quotations from the *Agricultural Animal Guide* and are duplicated with permission.

3. Copies of the *Agricultural Animal Guide* are available at a cost of $5.00 each from: Association Headquarters, 309 West Clark Street, Champaign, IL 61820 (telephone: 217-356-3182). The executive committee of the consortium welcomes comments on the guide which can be sent to: Agricultural Animal Care Guide, Division of Agriculture, National Association of State Universities and Land-Grant Colleges, One Dupont Circle, N.W., Suite 710, Washington DC 20036-1191 (telephone 202-778-0858).

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ETHICAL TREATMENT OF INVERTEBRATES

HOW DO WE DEFINE AN ANIMAL?

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As a member of the Animal Care Committee of the Animal Behavior Society, I receive manuscripts for review about ethical issues in animal care and/or treatment. We worry especially about causing what could be called "suffering", pain, or death of animals. The *Guidelines for the Use of Animals In Research* (Association for the Study of Animal Behavior/Animal Behavior Society 1986) specify that researchers should ensure that "pain or discomfort, even when unavoidable, should be minimized to the greatest extent possible", and that death should be "in as humane and painless a way as possible". However, regulations about animal care and guidelines for ethical behaviour imply and sometimes even specify that "animals" means "nonhuman vertebrates" (Orlans, Simmonds & Dodd 1987). This selectivity of animals about which we should care arises because we are, at heart, anthropocentric and see a *scala naturae* of evolution, culminating in humans (Fig. 1a). We care about the suffering of animals because we draw analogies with ourselves and even try to assess their suffering by imagining how we ourselves might feel (Dawkins 1980). We care about mammals because they look somewhat like us. We can empathize with a kitten's cry of pain, can imagine that a baby monkey might feel sad when it is separated from its mother and confirm this opinion by seeing its slumped posture, down-turned corners of the mouth and unreactive attitude. This empathy is important since without it people would not care for animals but it is difficult to extend it to animals unlike ourselves.

Why should we care about the suffering of invertebrates and, for that matter, how do we know when they are suffering or that they are even capable of such a thing? These are difficult questions to answer but worth a try. But it is first important to note that both by quantitative and qualitative standards we do no justice to the diversity of animals by redefining them as "nonhuman vertebrates". There is not one line of evolution leading to highly specialized animals, but four. Three of the four lines depicted in Fig. 1b, the Arthropods, Molluscs and Chordates, culminate in animals with centralized brains, variable behaviour, capacity to learn, and "intelligence". There are only 48,000 species of Chordates but 100,000 Molluscs, and approximately 890,000 Arthropods. Thus, a definition of animal as "nonhuman vertebrate" includes only a fraction (5%) of the species in the "intelligent" groups, even apart from all the other "lower" animals. In terms of numbers the fraction is much

smaller if we count how many ants there are in one colony, how many barnacles on a dock or clams in a bay.

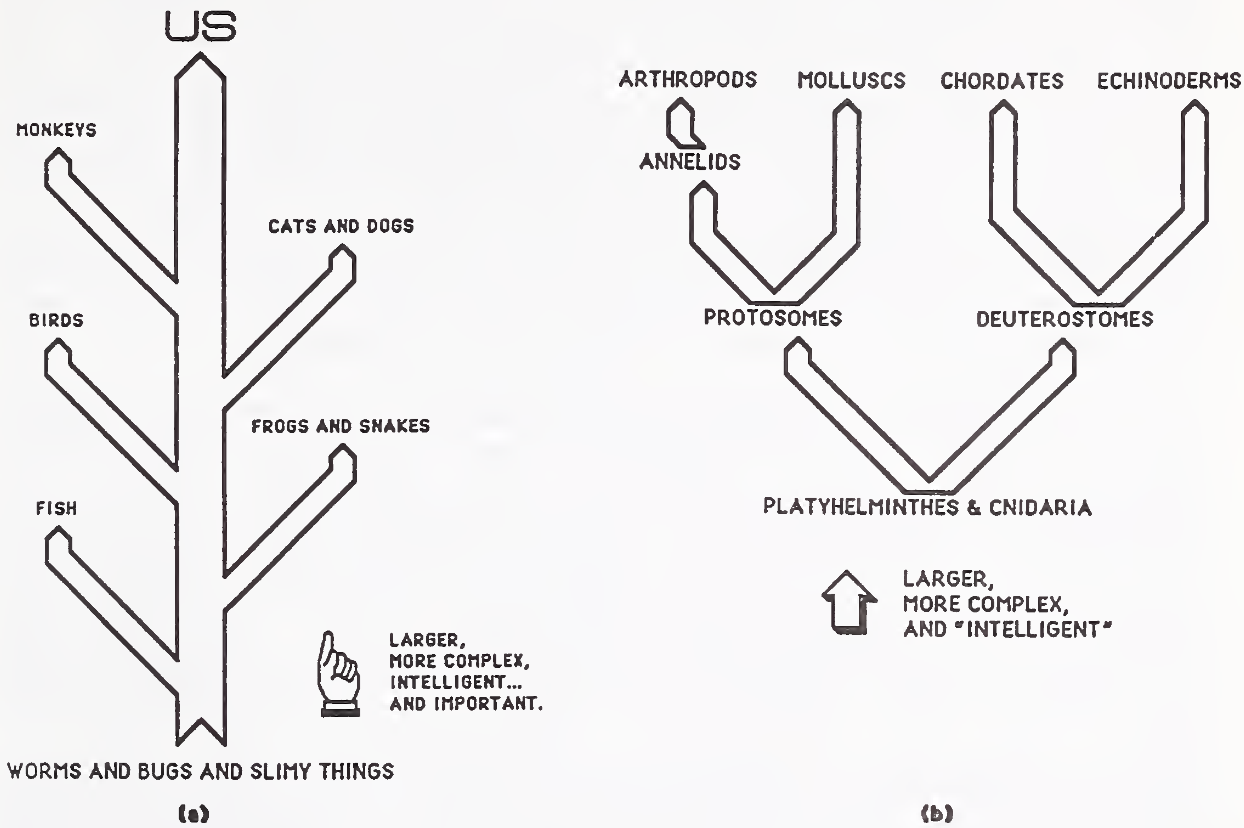

Figure 1. (a) The anthropocentric view of the evolutionary tree of the animal kingdom. (b) The true evolutionary paths of the animal kingdom.

If we nevertheless center our concerns for animals on qualitative standards, caring about those with an intelligent mind, perhaps with a grasp of the situations facing them, Rowan's (1988) "sense of the future", we can apply Griffin's (1981) definition of "mind" to these diverse animal groups. This definition would include some kind of awareness of self, a carryover of knowledge across time (so the animal could anticipate discomfort) and perhaps emotions or feelings. Griffin (1981) suggests that we cannot know animals' minds. In a practical sense, we may be able to find evidence of thought by monitoring animals' communication and by recording brain potentials from them which are similar to the ones accompanying human thought such as event-related potentials. The latter would be useless for comparison to invertebrates since their dissimilar brains would have dissimilar electrical activity , so we are thrown back onto observing their behavior and looking for clues to actions which we would see as mindful or at least purposive.

Latto (1986) argues that a direct approach to understanding animal consciousness is impossible since we can never know about it in another organism and cannot even ask an animal about its experiences (perhaps making an exception for the

signing apes?). We must turn instead to the indirect approach, of observing avoidant or responsive behavior and this approach is fragmented and subjective. He points out that these fragments of behavior, such as anticipation of events and production of misleading behavior, presume consciousness "because in our own, necessarily human, experience certain kinds of behavior are associated with certain kinds of conscious experience" (Latto 1986 p. 311). This empathetic parallel is hard to make for invertebrates. Indeed, Gould and Gould (1981) point out that what Griffin (1981) might see as "mind" behind the complex overt behaviour of insects may not be such consciousness. Instead, they argue that even complex and variable acts such as the dance of the honeybee could just be genetically programmed.

Even the learning shown by animals like the honeybee is sometimes evidence of a well-programmed behavior since it is selective for characteristics and situations which are evolutionarily adaptive and is useless outside these situations (which may be true for humans too). Gould and Gould (1981) suggest that this behavioral flexibility is only evidence of "larger, more interesting on-board computers". This suspicion about what is behind an action is evident also in Latto's (1986) comment that both "the burglar alarm and the policeman have representations of the burglar". The Goulds are also skeptical of human "awareness". They comment that we are mostly learning machines too but are occasionally able to use consciousness "to solve unexpected problems by formulating novel hypotheses; and ... to lie plausibly " (Gould & Gould 1981). Wells (1978) points out that we should find it easy to make parallels between octopuses' behavior and ours and empathize with them because of the similar behavior-responsiveness to stimuli, individual variation and visual-based reactions. Because of this and the octopus' capacity to learn, we may interpret its behaviour "in terms of concepts derived from birds or mammals" (Wells 1978 p. 9), which are nevertheless inappropriate. Thus, in the case of insect and octopus, we are trying to evaluate intelligent animal groups about whose mental processes we cannot make assumptions even based on parallels with ours. We have three recourses; to assume they have none as Gould & Gould (1981) do, or to make an assumption that they are different from us and wait for more data, or to presume they have.

If we could assume that invertebrates have no "mind" or "consciousness," does this then argue that we would have no moral obligation to them? Rollin (1985) contends that this is untrue. Both he and Dawkins (1980) argue that since there is no *scala naturae* (see Figure 1), no single "peak of evolution" and thus no grounds for evolutionary superiority of humans, we have no basis on which to judge the relative "worth" of different species. For those who argue animals are not worthy of consideration because we have souls and they do not (the Cartesian viewpoint), Rollin (1985) points out that we should then concentrate even more on making their earthly life pleasant. For those who point out we have the power and so can do what we like, he argues we should then feel obligated to act with more and not less consideration to animals in our charge and points out the Nazis had power over

the Jews. From this point of view, considerations of "mind" are interesting but ought to play no part in our obligation to act ethically towards the animals in our care.

Whether deciding that their research animals have awareness or not, most researchers attempt to minimize what could be called "pain and suffering" in them (Dawkins 1980). Carrying this out for invertebrates poses a number of practical problems. These center around the definition of pain, the physiological responses to tissue damage and the means whereby we can tell that an animal is "hurt" or "suffering". Merskey's (1983) definition of pain as "an unpleasant sensory and emotional experience associated with either actual or potential tissue damage, or described in terms of such damage" is used as standard by pain researchers. Because subjective assessment of reality is central to this definition, it is hard to apply the word to invertebrates whose subjective experiences must be, as Latto (1986) suggests, at the very least difficult for us to understand. We should instead talk of nociception, which is the capacity to detect and respond to stimuli which are potentially or actually tissue damaging (see Kavaliers 1988). Then we at least have a behavioral standard which can be applied across groups.

Do invertebrates show nociception? Kavaliers (1989) points out that even Cnidaria (sea anemones and jelly fish) have both behavioural and electrical responses to aversive stimuli; sea anemones have "wars" that lead to tissue damage and displacement of subordinate animals, and "pain" often appears to be the result when octopuses, crabs (McLean 1983) or even humans are stung by their nematocysts. Fiorito (1986) reports that many invertebrates respond to noxious stimuli by behaviors such as leg autotomy, escape responses, and avoidance, and the research on learning of octopuses (Wells 1978) was based on their avoidance of electric shock. Nevertheless, Eisemann et al. (1984) rightly point out that insects often do not withdraw after injury of body parts and many cases are known of internal parasites which literally eat the insect up from the inside. But we are again showing our anthropocentrism. Humans also do not always react with pain responses to tissue damage (see Melzack 1973), especially under hypnosis or stress-induced anaesthesia, and are in fact quite insensitive to radiation-induced damage. Other stimuli than those which bother us may be "aversive" to an insect or a mollusc (for instance, a too-bright ultraviolet light which is unseen by vertebrate eyes would be unpleasant for insects). It will probably be sufficient to say that many invertebrates have nociception because they usually withdraw from and subsequently avoid noxious stimuli.

Another argument for parallel "pain" systems in vertebrates and invertebrates is the parallel possession of opioid systems across a wide variety of groups (Fiorito 1986). One can certainly argue, as Eisemann et al. (1984) do, that these opioids are used for regulation of a number of physiological responses besides nociception and that they may be "used for" other physiological responses than pain in

invertebrates. But since the opiates do reduce nociceptive responses of many invertebrates (Kavaliers (1988) points out that morphine "makes snails sluggish"), the parallel of a similar "pain" system seems reasonable. With both physiological and behavioral similarities, a parallel sensitivity at least seems probable. Rowan (1988) makes a similar argument for a wide distribution of "anxiety" across vertebrates based on their possession of a benzo-diazepine receptor system.

Even given this similarity, the practical problems of telling when invertebrates feel "pain and suffering" are immense. Dawkins (1980) points out that we use physical health, physiological efficiency, abnormal behaviour, free preference in choice conditions, and, inevitably, a similarity to humans' responses in the same situation to get an idea if an environment is wrong for an animal. Physical health and physiological efficiency are the most obvious criteria for "well" though they require knowledge of the species; adequate utilization of food is a reasonable measure of well-being though it would be difficult to assess, for instance, if one has a healthy clam! Our assessment of abnormal behavior or free habitat choice of invertebrates is limited by our abysmal knowledge of their natural behaviour (How many octopuses are crowded? Do ants "need" to live in groups?). There are very few molluscan ethologists; there were three at the 1987 International Ethological Congress for about 100,000 species. Nevertheless, when recently two octopuses occupied one aquarium, one of the animals changed from its known daytime inactivity in a hidden location and took on a coloration previously associated with aversive stimuli, I had surmised before I saw the other animal attack it that there was a problem. We have to make parallels between ourselves and the animal in the situation (Dawkins 1980; Bateson in press) and ask "how would I feel?" even though the question is inappropriate. Expansion of our base of knowledge will gradually help us though without that knowledge it may be appropriate to consider what we would endure before we plan to inflict it.

Enlarging the scope of our consideration and our regulations to include invertebrates is not necessarily a drastic step. In the case of the Canadian Council for Animal Care (CCAC), such action was initiated by Gail Michener, a member of the board. She received a categorization of invasiveness of research from the Scientists Center for Animal Welfare (1987), which classed invertebrates in terms of consideration of animal welfare with "tissue". After informal contact with local researchers on invertebrates, she was asked to form an *ad hoc* committee to investigate the issue. She sent letters to other Canadian reseachers working with a variety of "higher" invertebrates. From these she suggested a revision to policy in March of 1988 (CCAC 1988). The lowest category of consideration, with tissue, is appropriate still for "most invertebrates", with the note that "some invertebrates have well developed nervous systems and respond to noxious stimuli and therefore must be treated humanely". No specific group of invertebrates is yet

specified for consideration, but it is also noted that it may be appropriate for Animal Care Committees to review protocols of some experiments with invertebrates. All researchers are urged to treat their animals ethically. Extending these considerationsto parasites, bacteria and viruses may be practically difficult - how do we balance the suffering of host and pathogen? The issues raised in this paper remain but at least in Canada, we have "permitted" non-vertebrates to join the animal kingdom.

SUMMARY

Recent advances in consideration of the welfare of animals and detailed plans for their care have generally been directed toward vertebrates, particularly mammals. Yet most animals are invertebrates, and some of these have complex nervous systems, excellent sensory capacity, and learning capability. Two problems face us when we extend ethical considerations to invertebrates. One problem is how we define "pain and suffering" for a non-vertebrate. All animals avoid noxious stimuli and molluscs have the same endorphin-based pain control system as vertebrates. If suffering implies consciousness, how can we conclude whether an animal has consciousness when its nervous system works differently from ours? Another problem is deciding which animals merit ethical treament. We may decide that a treatment which is unethical for an octopus does not cause suffering in a clam or a fly. But by making these value judgments, we impose a *scala naturae* on animals, suggesting they belong on an ascending scale of complexity and worth culminating in humans. Even discussing these problems will force us to examine our anthropocentric viewpoint; perhaps the only rule we can make in the face of diversity is "Respect your animals".

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SECTION III: PROCEDURES AND IMPROVEMENTS

The third section deals with suggestions and methods for improving the situations of captive animals and illustrates how knowledge of animal behavior is essential in creating suitable environments. In the first paper, Edward Gibbons and Michael Stoskopf describe problems which occurred when dolphins were prematurely transferred into a new facility in a public aquarium. They point out the need for interdisciplinary planning of facilities for captive animals. Next, Fred Koontz and Patrick Thomas discuss the contribution that ethological studies can make to improving the care of zoo animals. They illustrate this point with studies of giant pandas and proboscis monkeys

The last three papers explore the implications of the new "psychological well-being" provision of the 1985 amendments to the Animal Welfare Act. Melinda Novak discusses the problem of defining psychological well-being and offers some suggestions for promoting it in nonhuman primates. Kathryn Bayne carries this further, describing some of the advantages and disadvantages of many methods for enriching the environments of captive primates. Scott Line and his colleagues describe their investigations of enrichment alternatives for singly-caged animals, emphasizing the need for empirical rather than subjective evaluation of these methods.

AN INTERDISIPLINARY APPROACH TO ANIMAL MEDICAL PROBLEMS

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The effective treatment and resolution of animal medical problems is an important aspect of the care and use of animals in captive settings. A health care program should address not only the immediate medical needs of animals but must also consider environmental and social influences on health. This necessitates adoption of a multidisciplinary approach to animal medical problems. A purely pharmacological orientation, for example, may ameliorate the symptoms of an illness and enhance an animal's immediate health status but may not elucidate the underlying causes of disease or provide for a long-term solution to health problems. Knowledge of how underlying environmental and social influences affect health is necessary to develop effective husbandry and animal use practices.

The importance of an interdisciplinary approach to animal medical care was demonstrated in the management of a group of newly introduced bottle-nosed dolphins (*Tursiops truncatus*) at the National Aquarium in Baltimore who acutely developed gastritis and gastrointestinal ulceration. Medical treatment based on physiometry effectively ameliorated the ulcers but failed to prevent recrudescences of the problem. The rapid onset of behavioral and physiological deterioration in the dolphins prompted a study of the animals' behavior and key environmental factors when the dolphins were returned to the same environment after successful medical treatment. An interdisciplinary approach was necessary to identify health factors not identifiable by classic pathophysiological methods. The environmental components selected for examination were based on characteristics of dolphin behavior, evolution, natural ecology and past history in captivity. This case study illustrates how consideration of behavioral and ecological factors can be of importance to the physiological and psychological health of captive animals.

CASE HISTORY

Three female and one male adult Atlantic bottle-nosed dolphins (*Tursiops truncatus*) were wild-caught and acclimated to captivity for between 47 and 76 days at a facility near the

capture site in Texas. The acclimation periods were shorter than originally planned due to administrative pressures to open the marine mammal facility at the National Aquarium. The shortened acclimation period lessened the time the animals had to physiologically and behaviorally adapt to captivity and the close presence of humans. It also reduced the time needed to evaluate the health status of the animals. This was most evident in the oldest female animal, Gretal, who had abnormal serum chemistries and erratic eating patterns during acclimation. This animal was brought to Baltimore against medical advice.

The four dolphins were transported from Texas to the National Aquarium in Baltimore in two shipments and placed in the indoor marine mammal tray, the central exhibit on the first floor of the building. Visitors were able to view the dolphins from many vantage points around the tray, including an underwater viewing area (Fig. 1). The irregularly shaped tray measured approximately 25 meters by 11 meters and ranged in depth from 7 feet to 17 feet 9 inches. The tray contained 7122 cubic feet of water which was maintained at approximately 78 degrees F. and 30 ppt NaCl. The water was chlorinated at less than 0.3 ppm.

Table 1 summarizes the dolphins' medical histories during their initial introduction at the National Aquarium in Baltimore. The first indication that health problems may have existed occurred at 3 days after introduction of the animals to their exhibit. The male, Kibby, shattered one of many mirrors which

Table 1

Case History

Initial Introduction of
Bottlenosed Dolphins (*Tursiops truncatus*)
at the
National Aquarium in Baltimore

Individual	Arrival Date*	First sign of Behavioral Deterioration (Days)	First Diagnosis of Medical Problem (Days)	Medical Diagnosis	Initial Resolution
Kibby	7/22	3	55	Bleeding Gastric Ulcer	Medication & Transfer
Gretal	7/22	30	47	Bleeding Duodenal Ulcer & Internal Abscesses	Death
Aphrodite	8/7	30	41	Bleeding Gastric Ulcer	Medication & Transfer
Mimi	8/7	20	41	Bleeding Gastric Ulcer	Medication & Transfer

* The official opening date of the facility to the public was August 8, 1981 which was preceded by a week of pre-opening festivities.

lined the underwater surface of the tray. The mirrors were removed from the tray that day. The other animals; Aphrodite, Mimi, and Gretal also exhibited behavioral problems which became evident at 28, 30, and 44 days, respectively. These were characterized by a general loss of appetite and behavioral inactivity. The first signs of physical deterioration were documented between 41 and 55 days after arrival. The animals were anemic with leukocytosis and were diagnosed with duodenal and/or gastric ulcers. At this time they were removed from the tray to an off-exhibit holding area. Gretal was severely ill with complicating perivaginal lymph node abscesses and a valvular cyst in her heart. These problems were pre-existing but were exacerbated in the tray. Prior to her death, 70 days after introduction to the tray, Gretal was under intensive medical care which included systemic antibiotics, antispasmodics, antihistamines and alumina gel antiacids.

The medical problems of the other three animals were stabilized with double strength mylanta with simethicone and cimetidine and by removing them from the exhibit tray to an outdoor holding facility. When the animals were sufficiently stabilized to travel, they were flown to an open sea pen facility in Florida where medications were continued in a non-exhibit, low human visitation environment. All physiological signs stablized within 150 to 153 days after the original introduction of the dolphins to the indoor exhibit tray. The animals were maintained in Florida for an additional five months before being brought back to the exhibit facility in Baltimore. At that time, the animals were reintroduced into the essentially unmodified dolphin tray. Based on the likelihood of recurrence of the same medical problems, an interdisciplinary study of the dolphins and their environment was initiated in the hope of early detection of problems and identification of underlying causes.

METHODS

To facilitate observations of the dolphins at the Aquarium, a map of the exhibit was drawn and divided into nine areas designated as grids A through I. The boundaries between grids took advantage of natural divisions in tray structure to avoid using artificial markers that might have affected dolphin behavior. Seven visitor viewing areas were also delineated and were labelled 1 through 7.

Observations were conducted from 23 June, 1982 to 30 July, 1982, and encompassed the sampling of 230 hours. Data were collected between 0800 to 2225 hrs. by teams of two observers who each hour took 15 consecutive scan sampling observations at one-minute intervals. The observers were randomly paired with one observer assigned to record the behaviors and grid locations of the three dolphins and the other instructed to record the location, number, and behavior of the visitors at the exhibit tray. Both observers used the same sampling time frames and

recorded their observations on separate data sheets. A large number of observers (N=22), including several volunteers with no previous experience in marine mammal observation, were used in this study. The observers were trained by three of the Aquarium's staff mammalogists who had attained a high interobserver reliability (Kappa=0.97). The mammalogists trained each volunteer until the interobserver reliability score (Kappa) was greater than 0.90 over 3 consecutive observation periods.

In addition to data collected on the dolphins and visitors, data were collected on the light and sound intensities at the exhibit. Light intensities were measured with a photographic light meter at the estimated center of each water grid by reading, at one meter, the incident light reflected off of a floating white square with a reflectance (R) of 90%. These readings were converted to foot candles using the formula $(ASA*SS/8D^2)(2.34375E_f)*R$=Footcandles, where ASA represents film speed, SS is shutterspeed in seconds, D is the distance from the reflecting screen in meters, R is the percent reflectance of the reflecting screen, and E_f is the exposure factor of the F-stop read on the meter (i.e., F_4=16, $F_{5.6}$=32, F_8=64 etc.). Sound intensities in the tray were measured by a contract company using a Listening, Inc. MSA-1 spectrum analyzer to measure relative decibel (db) levels from recordings taken on Uher 4400 stereo and Uher IC recorders from an Atlantic Research Corporation Series 112 hydrophone placed in the centers of qrids A through I one meter below the surface. Measurements were taken with and without public in the building and with and without the filtration pumps operating. The reported decibel readings were relative db intensities.

To monitor physiological parameters, the dolphins were caught once each week and examined in a stretcher suspended above the water. Blood was drawn from the tail fluke and routine hematological and serological tests were run. The entire procedure took less than one hour each week and had no observable affect on the dolphins' behavior.

RESULTS

Physiological Condition

When the three surviving animals were returned to the tray, they were physically robust, free of outward signs of illness, and their hematological parameters had returned to baseline values in the range of other healthy dolphins. Over the course of the 38 days of the study, all three animals exhibited a gradual decline in hematocrit, hemoglobin, and erythrocyte count indicative of a recrudesence of their previous gastrointestinal problems. This decline was most pronounced in the last two weeks of the study and was the basis for terminating the study and transporting the dolphins back to their Florida recovery facility.

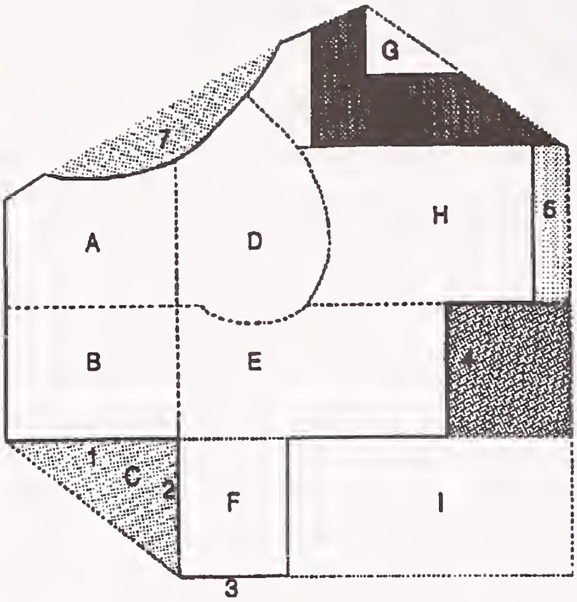

Figure 1:
Relative Visitor Utilization

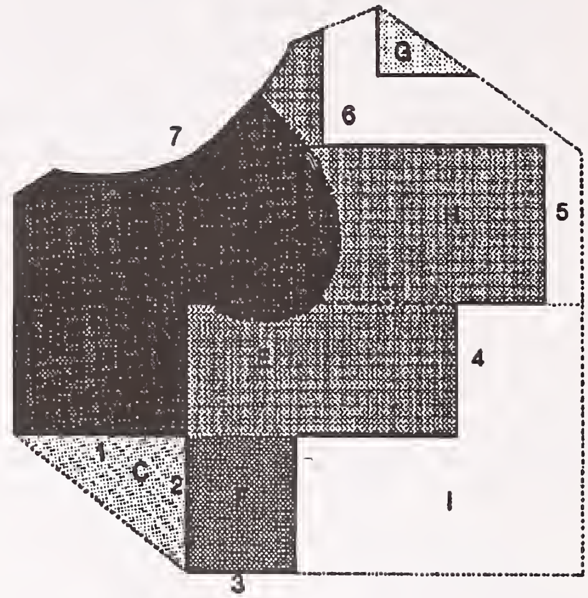

Figure 2:
Relative Dolphin Utilization

Figures 1 & 2 Legends:
Light shades = low utilization; dark shades = high utilization.
Numbers = public viewing area; letters = tray grids.

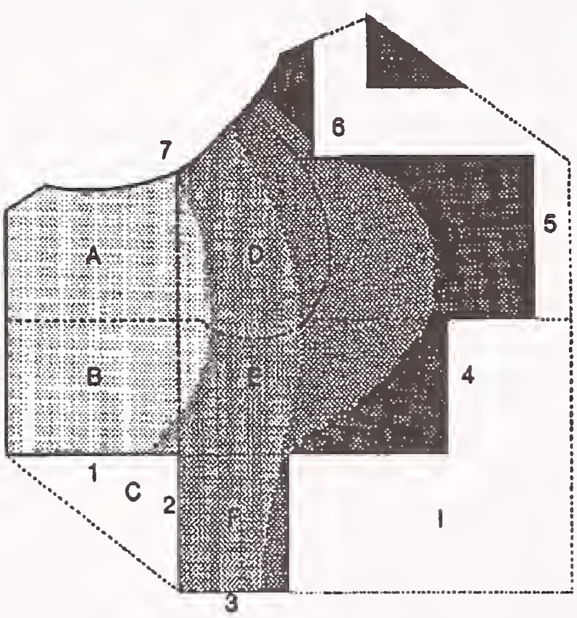

Figure 3:
Relative Light Intensity

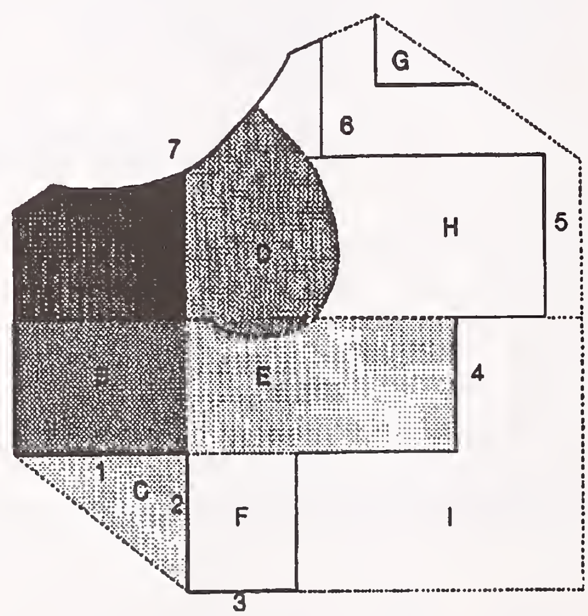

Figure 4:
Relative Sound Intensity

Figures 3 & 4 Legends:
Light shades = low intensity; dark shades = high intensity.
Numbers = public viewing areas; letters = tray grids.

Spatial Behavior

The distribution of the animals' spatial behavior on return to the exhibit is summarized in Figure 2. The darker shaded areas represent the grids utilized most frequently by the animals. The dolphins utilized grids A,B, and D (i.e. 40% of the exhibit) during 89% of the observations. The animals' usage of this space was significantly greater than expected by chance (binomial distribution, $p<.001$).

While inhabiting grids A,B, and D the dolphins engaged in a variety of behaviors such as swimming, resting, and play. Two behaviors were of particular importance. The first, "public watching" occurred when an animal positioned itself vertically or semi-vertically in the water and scanned the periphery of the tank. During this behavior, the dolphins did not approach visitor viewing locations. Approximately 89% of "public watching" occurred in grids A,B,D, and of this percentage 73% occurred when there were 30 or more visitors at the exhibit. The second behavior, tail slapping occurred when an animal suddenly submerged with a violent blow to the water surface. This behavior occurred in all but one instance in grids A,B,D (i.e. 14 of 15 instances), and was associated with higher number of visitors at the exhibit. Indeed, 67% of all tail slaps occurred when visitor numbers were 30 or greater. Without simultaneous physiological data we cannot state positively that the occurrence of these behaviors were indicative of stress but we believe that this was the case.

Spatial Behavior and Visitor Densities

Visitors viewed the dolphins from 7 locations around the tank (Fig. 1). The total number of visitors at the dolphin exhibit ranged from 0 to 100 with a mean visitor density of 24.85 (S.D.=25.05). Locations 4 and 6 were most utilized with over 20 visitors found on 150 observations. In contrast, locations 1,2, and 7 were the least used with more than 20 visitors counted on only 33 occasions. These latter three locations were closest to the grids that the dolphins most frequently inhabited.

Light

The light intensity over the tray was very low. Over most of the exhibit light intensity was less than 19 ft. candles, and ranged from 4 foot candles in grid H to 31 foot candles in grids A and B (Fig. 3). The grids of highest light intensity (i.e. A and B) were also those the animals were observed to most frequently inhabit.

Acoustical

Underwater sound pressures with pumps on and public in the building ranged from -18db in grid G to -8db in grids A,B and D. The majority of the sound intensity was under 10KHz, extending up to 20KHz, well within the hearing range for

dolphins. As indicated in Fig. 4, the areas of highest noise intensity were grids A,B and D, the grids most frequently inhabited by the animals. Underwater measurements taken with the filtration pumps off indicated no appreciable change in sound intensity levels. The majority of the noise in the water was attributable to human activity in the building.

DISCUSSION

The physiological decline of dolphins on initial introduction to the National Aquarium's display facility was readily attributable to gastric and/or duodenal ulceration. While this condition was controllable with pharmacological management, it could not be resolved completely in the environment of the display, suggesting the contribution of one or more environmental and/or social factors to the problem. For this reason, return of the animals to the facility after over six months recuperation in another facility prompted the application of a multidisciplinary approach to studying the situation.

This multidisciplinary approach included physical monitoring of environmental light and sound intensities, physiological monitoring of hematological and serological parameters, and behavioral studies of spatial utilization, social interactions, individual behaviors, and public/dolphin interactions. The integrated examination of data from each of these disciplines provided a much more complete picture of the nature of the problem than would have been possible relying on one discipline. This in turn allowed more effective counsel regarding long term correction of the problem, and more accurate prognostication of the impact of various modifications to the facility to improve its suitability for maintaining marine mammals.

Significant deviations from normal spatial patterning can be expected when environmental conditions are suboptimal and these deviations can serve as indicators of illness in animals (e.g. Hediger 1969; Markowitz 1982). Spatial pattening can also serve as a valuable tool to help establish the relative impact of environmental factors on health. Observations of the dolphins in these studies suggested they were restricting their spatial behavior to a small portion of their available environment. Although the physiological decline was incontrovertibly established by the decline of hematological parameters (data not presented), the data from the animals' spatial utilization patterns provided earlier detection of the problem. They also provided adjunctive insight into the relative importance of the various social and environmental factors thought to contribute to the physical condition of the animals.

During observations, the animals inhabited grids A,B and D disproportionately often (Fig. 2). These grids had the highest underwater sound intensities (Fig.. 4). From these data, it appeared that any postulated negative effects of the sound levels

measured in the tank were outweighed by positive effects of being in these grids.

Although the increased light intensity in grids A,B and D (Fig. 3) is proposed to be a beneficial factor, these three grids were furthest from the viewing locations (i.e., 4 and 6) most utilized by visitors during the study period. Analysis of the individual dolphin behaviors provided additional evidence that the viewing public contributed importantly to the animals' physiological problems. When 30 or more visitors were viewing the exhibit tray, the dolphins increasingly displayed behaviors suggestive of stress ("public watching" and tail slapping). When visitor densities at the tray were high, no deleterious social interactions occurred among the dolphins.

An assessment of the behavioral, physical and physiological data allowed postulation that the presence and relatively close proximity of the viewing public significantly affected the animals' behavior and must be considered contributory to their medical problems. The impact of visitor density and proximity apparently outweighed the negative impact of underwater sound pressure. The influence of the short post-capture acclimation period for these animals and their rapid introduction to high density crowds could not be determined from these studies but was believed to have contributed to the sensitivity of these animals to visitor stress.

SUMMARY

This study illustrates the importance of an interdisciplinary approach to animal management in captivity. A number of specialists must appreciate and value the talents of different disciplines to resolve complex problems such as the one presented here. Administrative specialists must be attuned to the general inflexibility of the limits of adaptation for biological systems when making fiscal decisions for aquariums or zoological parks. They must also understand the value of investing in the identification of underlying causes when a biological problem creates a business dilemma. Veterinarians must recognize the potential impact of psychological and environmental factors on the course of physiological disease when making a diagnosis or prescribing therapeutic measures. They must also be prepared to benefit from the input of animal behaviorists and environmental physicists in seeking an answer to a medical problem. Animal behavior specialists must understand the value of quantitative assessment to administrators, veterinarians, and scientists of other disciplines and must be able to identify key physical and social (including interspecies) factors which can adversely affect behavior. Environmental physicists must work within the limitations and demands of a failing biological system to provide rapid and useful evaluation of a problem in a cost effective manner. Successful identification, evaluation, and resolution of complex biological

problems in captive environments depends upon the cooperation and mutual respect of all of these professionals.

NOTES

1. We thank the staff of the National Aquarium in Baltimore for their cooperation during this study.

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APPLIED ETHOLOGY AS A TOOL FOR IMPROVING ANIMAL CARE IN ZOOS

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It is clear that humankind is faced with a biological extinction crisis (Wolf 1987; Wilson 1988). Extrapolation of current trends in the reduction of biodiversity suggests that within a century the Earth's biota could be as impoverished as that of a nuclear winter (Ehrlich 1988). Less clear, however, is what steps must be taken to reverse these trends in order to prevent catastrophe. The traditional answer of setting aside protected nature reserves, while important, alone is almost certain to be inadequate because of factors such as runaway human population growth, acid rain and global warming (Ehrlich 1988). The truth of the matter is that there is no one answer, no one correct conservation approach. Instead, maintaining biological diversity will require a more holistic, multi-discipline, global effort. Zoos and ethologists should be important members of this environmental management team.

Over the last 15 years, several scientists have urged ethologists to conduct, and zoo administrators to finance, behavioral research in zoos in order to improve captive breeding programs (Kleiman 1974; Eisenberg & Kleiman 1977; Kleiman 1980; Hutchins 1988). Despite these recommendations, participation by ethologists in zoo-based studies remains modest. For example, at the 1987 International Ethological Conference (Madison, WI), only four of the 485 papers delivered applied their findings to species conservation and only one of these studies was conducted at a zoo. In the midst of an extinction crisis, this is regrettable.

The American Association of Zoological Parks and Aquariums (AAZPA) defines a zoo as: "an organized and permanent institution, essentially educational or esthetic in purpose, with professional staff, which owns and utilizes wild animals, cares for them, and exhibits them to the public on a regular schedule." On this basis, there are about 600 zoos in the world, with more than 100 of them in North America (Conway 1982). North American zoos average 52 acres in size and have an attendance greater than that of professional football and baseball combined (Conway, 1982). More importantly, many zoos have broadened their mission to include species conservation (Rawlins 1985).

The genetic and demographic management of endangered species maintained in captivity has improved dramatically in the last two decades (Benirschke 1985; Foose & Ballou 1988; Flesness & Mace 1988). In the late seventies, the AAZPA developed the

Species Survival Plan (SSP) as a tool for coordinating the management of rare species maintained in North American zoos. These taxon-specific-plans are administered by a committee whose members represent the institutions holding that taxon (for SSP examples, see Sheppard 1988; Wharton and Freeman 1988). The SSP committees are responsible for overseeing the taxon's captive population management and for developing its husbandry standards. The hope of all SSPs is for the eventual reintroduction of the taxon to the wild, if necessary.

It has been estimated that within the next century, 2000 mammals, birds, and reptiles will require captive breeding to prevent their extinction. Unfortunately, the carrying capacity of existing zoos is limited to about 900 vertebrate species (Soule et al. 1986). There are currently only 42 SSPs managed by the AAZPA, but the goal is for 200 SSPs by the year 2000. Regardless of the exact numbers, zoos undoubtedly will contribute increasingly to preserving biological diversity by maintaining endangered species in captivity, until such time that they can be reintroduced to nature. We believe that ethologists could participate more widely in the SSPs and similar captive breeding efforts, especially in regards to improving animal care.

APPLIED ETHOLOGY AT THE BRONX ZOO

Applied Ethology: A Definition

Most ethologists use the phase "applied ethology" to describe animal behavior studies in which the goal is to incorporate research findings into farm animal management. Typically, the animals are members of domestic species and the study objective typically is to reduce animal suffering. Some ethologists have broadened this traditional definition to include behavioral studies aimed at improving the welfare of captive wild animals, especially endangered species maintained in zoos (Altmann & Sorensen 1987; Moran 1987). For purposes of this paper, "applied ethology" is defined as: the process of employing the theory and methods of ethology for the purpose of improving animal management programs; the study animals, captive or free-ranging, can be from domestic or wild species.

Applied Ethology Research Topics

The modern zoological park staff cares for its animals through a team of zoo professionals. This group includes, among others, accountants, curators, educators, field biologists, keepers, nutritionists, reproductive biologists and veterinarians. Ethologists also can be important members of this team.

Broadly speaking, ethologists can contribute to animal management in two general ways. First, they can bring the body of behavioral literature into the management decision-making process.. Especially important is the ethologist's knowledge of animal aggression, behavioral ontogeny, communication, learning

mechanisms, mating systems, social organization and reproductive behavior. Second, ethologists can contribute to improving animal programs by conducting applied ethological research on zoo-housed animals.

At the Bronx Zoo, our research is focused on four areas: (1) behavioral description, (2) social behavior, (3) reproductive behavior and (4) perinatal monitoring of mother and offspring. Regardless of the study topic, the goal always is to optimize animal keeping methods. Success is measured by improved animal longevity, reproduction or well-being.

Our most important research priority at this time is behavioral description. Regrettably for most captive animals, their behavioral biology is not completely described. Activity rhythms, ethograms, ontogeny patterns, time budgets and sociograms have been published for relatively few zoo animals. Of course, it is this descriptive behavioral foundation that is so necessary in order to interpret more complex ethological analyses or to test better animal care practices.

Quantified behavioral description should be included in the animal keeper's normal-animal-baseline; it is against these normal baseline behaviors that keepers monitor their animals. By way of analogy, consider how a physician requires normal physiological values when diagnosing medical cases. Similarly, modern animal keeping, especially for species that can not be routinely examined in-hand because of their large size or delicate nature, requires behavioral baseline values in order to reliably judge an animal's health status.

A second research focus is social behavior. Knowledge of a species' social requirements is a prerequisite for successful animal care and captive propagation (for review, see Kleiman 1980). Historically, failures in maintaining species in captivity were often the result of a misunderstanding of the species' social organization or mating system (Kleiman 1980). While much of this information can only be obtained from detailed field studies, sociobiological research conducted with captive animals can sometimes fine-tune our understanding of a species' behavior (for example, see Lumpkin and Koontz 1986).

Social behavior research in zoos has concentrated on questions of social dynamics and animal communication. We suggest that a greater emphasis be placed on more applied questions leading to improved social management. For example, a common problem faced by zoo managers, including many for SSP species (where animal transfers for genetic management are common), is how best to introduce unfamiliar animals to each other. Unfortunately, there have been few studies of how zoo keepers should carry out such social introductions and, as a result, decisions often are made subjectively.

A research focus that is especially important for establishing long-term breeding programs is reproductive behavior. An understanding of species specific reproductive

parameters is required to design management programs that maximize the chances for successful reproduction. For many mammals, even knowing when to place males with females is poorly understood. Additional research, however, for many of these species might reveal that season, time of day, activity levels, food intake or specific behavioral patterns correlate with estrous cycles. Behavioral research on captive giant pandas, for instance, led to a better recognition of female heat (Kleiman 1984), a skill needed when pairing pandas for breeding or when timing attempts at artificial insemination. Other often cited topics requiring study in relation to their effect on reproductive behavior include: Animal communication, diet, environmental parameters (e.g. light and temperature), exhibit design, genetic relatedness, mate choice, and social group size.

Every birth of an endangered species is an important event. With each birth, the zoo keeper must monitor the health of the infant and be prepared to medically intervene if necessary. These decisions, whenever possible, should be based on data collected from previous successes and failures. Far too often zoo biologists have neglected to collect, analyze and publish perinatal data. Zoos seem especially reluctant to publish failures. Often valuable perinatal information is relatively simple to collect. For example, we believe that nursing rates, descriptive patterns of parental behavior and behavioral infant ontogeny can be largely studied within the context of a keeper's daily work schedule.

Some ethologists have avoided working at zoos and have criticized our work because of the typically low sample sizes. We agree that this is a serious handicap. However, the value of "case studies" should not be underestimated. The benefits of case studies always have been appreciated in the medical sciences and we think that case studies eventually will be better accepted in conservation biology. A case study may not be science in the strict sense, but if done with a scientific approach, and if the limitations of the conclusions are noted, such efforts may mean the difference between failure and success for an endangered species propagation effort. Furthermore, zoos increasingly are collaborating on research projects in an effort to increase sample size and thus allow for more general statistical conclusions to be made.

APPLIED ETHOLOGY AND ZOO ANIMAL CARE: EXAMPLE CASES

Giant Panda Behavioral Description

In the summer of 1987, the Bronx Zoo hosted a six-month temporary loan of two giant pandas (*Ailuropoda melanoleuca*) from the Beijing Zoological Gardens, People's Republic of China. More than one million guests viewed these endangered animals, and learned of efforts being made to save the species from extinction. There are now fewer than 1,000 free-ranging giant pandas in nature and about 100 living in captivity, mostly in Chinese zoos and breeding centers (Schaller et al. 1985).

While the two giant pandas, "Ling-Ling" and "Yong-Yong," were under our care we felt a special obligation to monitor their health as closely as possible. For this reason, we paid special attention to descriptive behavior studies that were designed to detect panda health problems by discovering changes in normal behavior. A "normal behavioral profile" was determined for each animal against which these changes could be measured. This profile consisted of four parts: (1) circadian activity rhythm, (2) daily patterns of feeding and elimination, (3) behavioral time budget analysis, and (4) spatial use of the exhibit.

In April 1987, when the pandas arrived in New York, the male Ling-Ling was 18 months old, and the female Yong-Yong was six years old. The two pandas were not socially compatible so they were housed separately indoors at night and displayed individually in an outdoor habitat each day. Ling-Ling was exhibited in the morning and Yong-Yong in the afternoon. The roughly rectangular habitat measured 26 meters at the widest point and 18 meters from front to back. The enclosure was planted with natural grasses, bamboo and various trees, and it included a stream, rocky cliffs and fallen logs for the pandas to explore. The zoo visitors were separated from the animals in the front by a dry moat and the other three exhibit perimeters were secured by a 2.5 meter wall.

The circadian activity rhythms for both giant pandas were determined by conducting three 24-hour watches in which each panda's behavior was noted at one-minute intervals as "active" or "resting." For both Ling-Ling and Yong-Yong, these observations revealed polycyclic activity rhythms, but on average, peaks were noted at dawn, late afternoon and midnight. These circadian patterns were similar to those reported for giant pandas studied by others (Kleiman 1983; Schaller et al. 1985; Thomas 1987).

On a daily basis, the giant pandas' keepers recorded on a data form information concerning the animals' feeding and elimination patterns. These reports were reviewed each day by the entire panda management team and included: (1) amounts of food offered and amounts consumed by each animal; (2) air temperature and humidity of the outside and inside habitats at 0900, 1200, 1500 and 1800 hours; (3) daily stool descriptions for each panda; and (4) any unusual behaviors that were noted. These reports, especially feed intake and stool description, proved useful in detecting the onset of several minor gastrointestinal illnesses that occurred during the pandas' visit.

In order to quantify Ling-Ling's and Yong-Yong's behavior, an ethogram was compiled based on preliminary observations and a behavioral repertoire published by Kleiman (1983). Our ethogram included 35 behavioral patterns, based on mechanics and structure (after Wemmer et al. 1983), that were arranged into eight, higher-order categories grouped by probable function: Resting, locomotion, feeding, care of the pelage, elimination, scent marking, stationary activities and other activities.

Behavioral time budgets were calculated by analysis of video recordings made while the pandas were on exhibit in the outdoor habitat. The animals were recorded in one-hour segments; Ling-Ling always between 1000 and 1200 hours, and Yong-Yong between 1400 and 1600 hours. A total of 155 hours (Ling-Ling, 81 hours; Yong-Yong, 74 hours) were sampled over a 158-day period. Each panda was recorded at least three times per week. As the video tapes were reviewed, a complete record analysis was made by entering a numerical code into a microcomputer every time the panda changed behavior. The computer kept an ordered list of the behaviors together with the times of occurrences, upon which various time budget analyses could later be performed (after Koontz, 1982). In addition, at five-minute intervals, the panda's spatial position was recorded (using specially prepared exhibit maps) as an X-Y-Z coordinate, with the geometric origin set at the front-left-bottom exhibit corner (after Koontz et al. 1986).

The behavioral time budgets and spatial analyses revealed, among other things, that: (1) six behaviors accounted for over 98% of the observations; (2) Ling-Ling was active only 38.1% of the time, but Yong-Yong was active 68.2% of the time; (3) the older Yong-Yong spent more time feeding on bamboo, but Ling-Ling spent more time grooming; (4) Yong-Yong's "moving" was inversely correlated to air temperature; (5) Ling-Ling spent the majority of his time resting in one particular tree; and (6) Yong-Yong utilized a larger exhibit area than Ling-Ling. It is important to remember that the purpose of the analyses really was not to make such comparisons nor to draw general conclusions about giant panda behavior, but simply to understand these two animals better so that we could improve their care.

In order to track daily behavioral trends, we borrowed from industrial control methodology the concept of a "control chart." This technique consisted of plotting the daily time budget values recorded for a particular behavior along with the behavior's overall study mean and its statistical upper and lower control limits (defined here as $\pm$ one standard deviation). These charts allowed zoo managers to compare daily values against normal value ranges, in hopes of detecting shifts towards unusual and possibly unhealthy behavior. See Fig. 1.

Proboscis Monkey Social Behavior

The proboscis monkey, *Nasalis larvatus*, is an endangered, leaf-eating, arboreal primate, endemic to Borneo, inhabiting riverine and coastal mangrove forests (Wolfheim 1983). At present, the Bronx Zoo's four males and five females are the only captive proboscis monkeys in North America. At the Zoo, this species is housed in social groups of one adult male, one to five adult females and their immature offspring. As for any social species maintained in captivity, it is necessary to monitor carefully the social relationships among troop members.

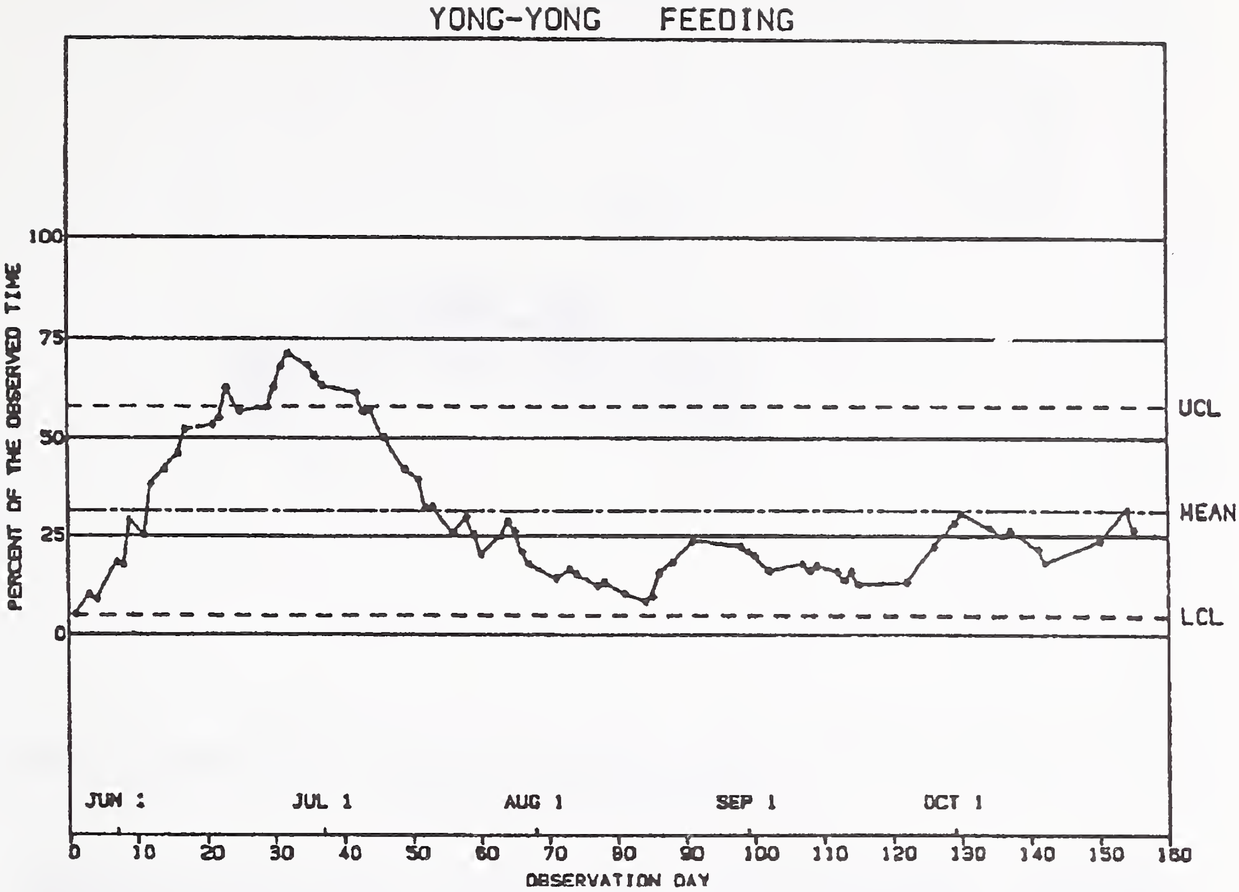

Figure 1. Example "control chart" from 1987 giant panda study. Daily time budget percentages were plotted in relation to the overall study mean and upper and lower control limits (defined here as ± one standard deviation). Shown here is female Yong-Yong's feeding behavior. (Note that in early July her consumption of bamboo was unusually high.)

The proboscis monkeys are displayed in "The Mangrove Forest" at the Bronx Zoo's JungleWorld. This naturalistic exhibit fits approximately within a rectangular volume 24 meters by 13 meters by 12 meters (length by width by height). The monkeys, however, are confined to a smaller central core area. The remainder of the exhibit includes a freshwater pool, artificial rocks and cliffs and several planters for live trees and bushes. Also, displayed in the exhibit are Asian small-clawed otters, Bali mynas, golden-fronted leaf birds and laughing jay thrushes. The zoo guests view the exhibit from a wooden walkway, running the length of the exhibit, which is separated from the mammals by both a pool and a waist-high glass barrier.

In order to document both the social behavior and spatial distribution of our proboscis monkey troop, we devised a scan sampling scheme in which, at 5-minute intervals, an observer

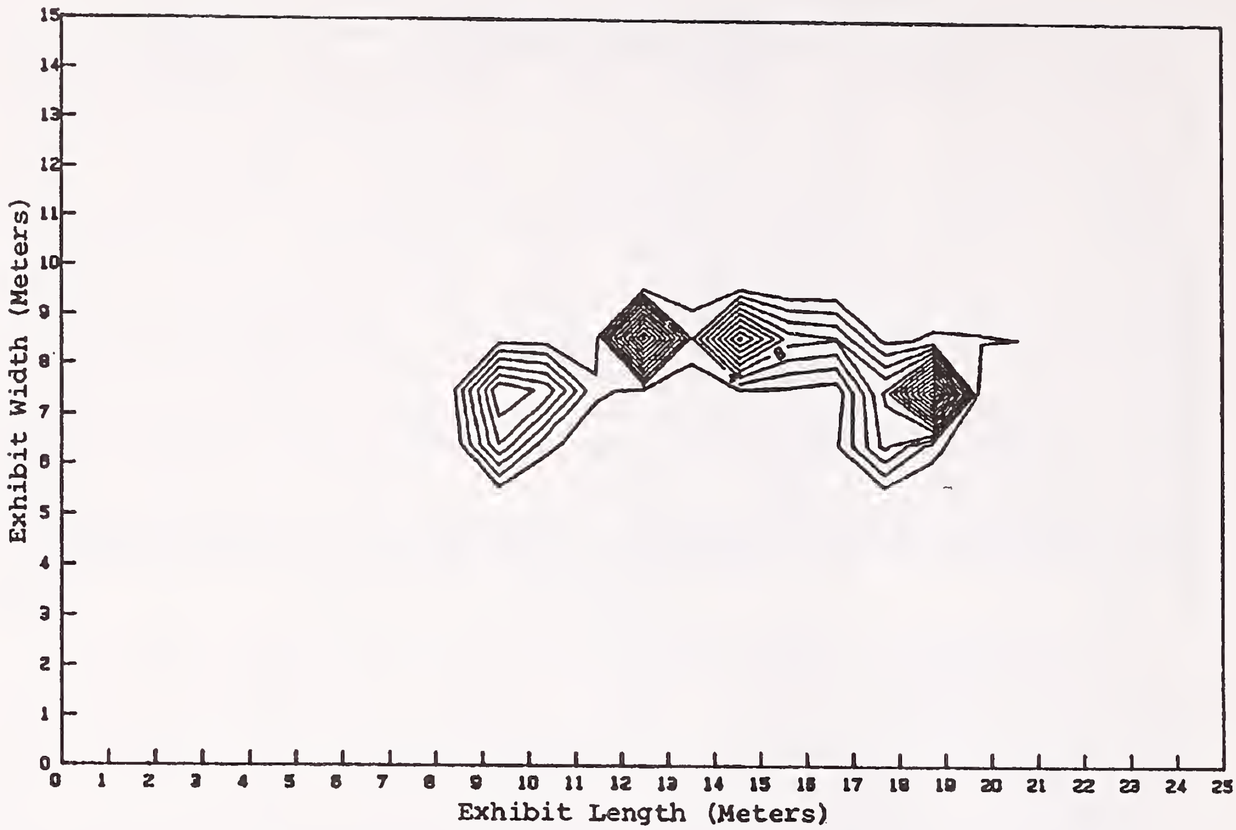

Figure 2. Top view of the male "Basel's" spatial use of the proboscis monkey habitat. Contour lines represent areas of equal activity use. The four "mountains of activity" reveal that most of Basel's time was spent in four artificial mangrove trees.

marked each monkey's location on specially prepared maps. The observer also measured with an optical range finder, the observer-to-monkey distance for each animal. Later, these map locations and distance data were entered into a microcomputer database, which in turn, transformed the data for each animal/location into X-Y-Z coordinates, with the lower left hand corner of the exhibit being assigned to the geometric origin. Once the database was built, it could be explored in many ways (e.g. social separation distances and exhibit use patterns) using the computer to examine the social and spatial relations among the animals (for additional details, see Koontz et al. 1986).

In one study conducted in 1986, 200 troop scans (1200 monkey locations) were analyzed to better understand the social dynamics between the troop's male ("Basel") and the five females ("Mom, Aunt, Bern, Dallas and Iris"). For example, from this study we learned that (1) Basel on average positioned himself between the visitors and the troop's females; (2) Mom and her 18-month-old daughter, Bern, were located the closest to the troop's geometric center, and had the smallest separation

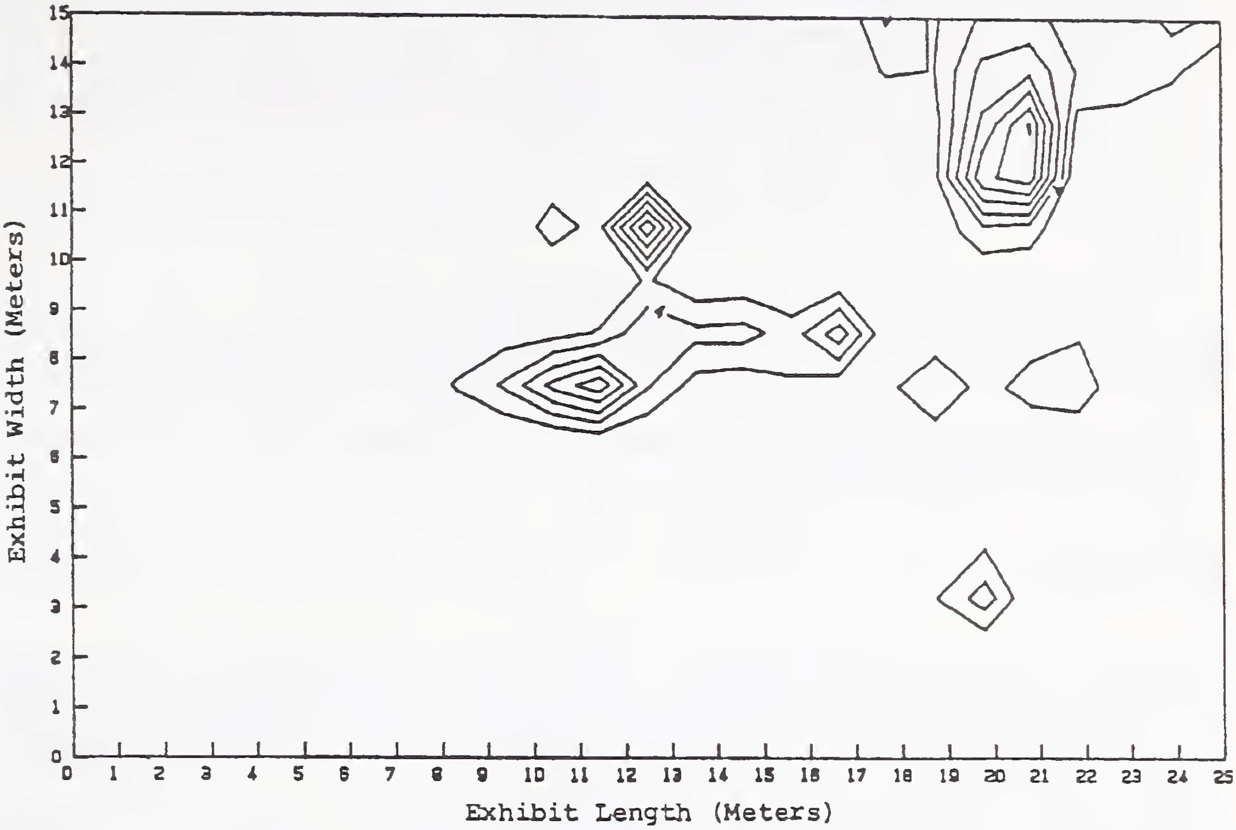

Figure 3. Top view of the female "Iris's" spatial use of the proboscis monkey habitat. Contour lines represent areas of equal activity use. The activity areas indicate that a major portion of Iris's time was spent isolated from the troop in the back of the exhibit, behind several artificial rocks.

distance; and (3) spatial use of the exhibit varied among the individuals. Especially surprising was Iris's prominent use of the exhibit's periphery (compare Figs. 2 and 3). Cluster analysis of the data, based on the similarity between the monkey's relative distances from the geometric center, revealed three social sub-groups: Basel and Dallas; Mom, Bern and Aunt; and (again) Iris was alone. The study, therefore, had detected a subtle social ostracism of three-year-old Iris from the remainder of the group. As a result, keepers were instructed to pay special attention to this situation. Eventually, a new male ("Ed") replaced Basel. The study was repeated and this time, we found that Iris was integrated well within the troop's social structure.

SUMMARY

While it is not new to recommend studying ethology at zoos (for example, see Eisenberg 1975; Kleiman 1980), we suggest that there is a continuing, and growing, need to conduct applied ethological research directed at improving animal management procedures. As environmental problems magnify in the future,

humankind increasingly will be forced to actively care for endangered species, both in zoos and in nature. As human intervention becomes commonplace, in order to manage the Earth, it is important that the results of ethological studies be incorporated into animal care procedures.

NOTES

1. We thank the many Bronx Zoo keepers who participated in the studies mentioned in this paper, but especially Louise Gillespie, Pam Manning, Bill Sheshko, Scott Silver, Laurie Thomas, Kim Tropea and Claudia Wilson. Special thanks also to zoo volunteers Charles and Helen Koontz.

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PSYCHOLOGICAL WELL-BEING: APPLICATIONS TO SOCIAL GROUPS OF NONHUMAN PRIMATES

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The use of animals in research has become a controversial and contentious topic of debate between scientists and animal rights activists. Whereas researchers point to the substantial benefits of animal research accruing to humans and other animals, activists question both the morality of animal use as well as the quality of life experienced by animals in laboratory settings. In buttressing their arguments, activists frequently paint a distorted picture of scientists and research laboratories, one of uncaring, indifferent researchers studying irrelevant processes in helpless animals maintained in bleak environments. Despite the inaccuracies of this view, scientists have not been quick to rebut these claims in the popular press (Snyder 1989). As a result, a certain ambivalence has developed in recent years even among the majority of the public that still favors the use of animals in research. It is within this climate of opinion that scientists face increasing regulation over scientific endeavors. The new primate psychological well-being provision of the revised Animal Welfare Act of 1985 is merely a reflection of these times.

Psychological well-being, then, is a phrase that primatologists have now inherited from Congress. The new provision of the Animal Welfare Act specifically requires primatologists to "provide a physical environment that promotes the psychological well-being of captive primates" (Animal Welfare Act 1985, Part 1752). This phraseology goes beyond the well-established boundaries of humane care and treatment of research primates into an area where considerably less is known and outcomes are variable. While this new legislation has a worthy goal -- the consideration of the mental state of the animal -- implementation of such a provision poses many formidable problems and is based on the presumption of specific knowledge and techniques that are not necessarily available.

DEFINITIONS AND MEASUREMENT OF PSYCHOLOGICAL WELL-BEING

In the several years since the new legislation was proposed, researchers and regulators alike have grappled with the problem of defining and recognizing psychological well-being in nonhuman primates (Wolfle et al. 1986; Line 1987; Novak & Suomi 1988). Their approaches, however, are quite different. Whereas many researchers are trying to define well-being in functional terms (e.g., the mental state of the animal), regulators want to

characterize well-being in terms of physical structure (e.g., increased cage size, presence of perches, etc.). Although both of these viewpoints are interrelated to some degree, function must take precedence over structure in this case (Sackett 1988). The problem of measuring and defining psychological well-being in nonhuman primates has to be solved first so that we can then evaluate the impact of structural alterations such as cage size in a meaningful way.

The functional approach requires that psychological well-being be defined on the basis of responses which accurately portray the animal's emotional, physical and cognitive state. As such, dictionary definitions (e.g., happiness or contentment) are simply inadequate and incomplete based as they are on the human condition. An alternative strategy employed by Novak & Suomi (1988) is to operationalize psychological well-being in terms of potential nonhuman primate response systems. We have identified four global systems which taken in some combination might be used as measures of psychological well-being. These response systems include physical health, behavioral repertoire, stress and coping strategies. Although each of these variables can be quantified in some way, it is incorrect to assume that these individual response systems are perfect or necessarily adequate measures of psychological well-being.

Physical Health

Physical condition can be assessed in nonhuman primates in a number of different ways. Both external signs (e.g., coat quality, condition of the eyes, nose and mouth) and physiological measures (e.g., blood hematocrit, hormone levels) provide a highly accurate picture of nonhuman primate health (Keeling & Wolf 1975). However, little is known about the precise linkage between physical health and psychological well-being. Although physical and mental condition are positively correlated, an assessment of physical condition may not always be predictive of psychological state. Depending upon the circumstance, primates in good physical condition might be mentally unwell, while primates in poor physical condition (e.g., aged monkeys with arthritis) might nonetheless have positive mental outlook. Physical health, by itself, cannot serve as the measuring stick for psychological well-being.

Behavioral Repertoires

Primates have a diverse and broad species-typical behavioral repertoire which is acknowledged to be limited and constrained in some laboratory settings. Some researchers argue that mental well-being is related to the range of the species-typical patterns exhibited by laboratory animals -- the wider the repertoire, the greater the mental health of the animal (Markowitz & Spinelli 1986). Although there is validity to this view, it raises many unexplored questions. For example, what is meant by the phrase "range of species-typical behavior patterns?" Should the focus be on mere occurrence or are frequencies and

durations more critical? In this context, with whom are we comparing our laboratory animals? Is the relevant comparison group free ranging primates, normally-reared laboratory primates housed in complex social groups or primates housed in presumably "enriched" environments? Finally, not all behavioral responses promote well-being. Aggression and its resulting wounds and injuries can lead to ill-being in the recipients. Thus, the tacit objective is to shape the repertoire so that a particular behavioral profile emerges (e.g., high levels of affiliation, reproduction, exploration and low levels of aggression and disturbance behavior) rather than to widen the repertoire in a general sense. At issue is the extent to which different behavioral profiles actually reflect psychological well-being in nonhuman primates.

Stress

Reducing stress in laboratory primates is an important goal of many primate researchers, the assumption being that stress and psychological well-being are inimical to one another (Moberg 1985). However, two points somewhat weaken this assumption. First, stress can have both enhancing and deleterious effects, a point made by Selye (1974) when he subdivided stressful stimuli into positive (eustress) and negative (distress) categories. Although there should be a concerted effort to eliminate distress in laboratory primates, periodic stress is a ubiquitous feature of most primate societies (both human and nonhuman) and its total absence may be no more desirable than its presence. Second, the actual linkage between stress and psychological well-being has not been fully explored. Although distress is thought to be the opposite of psychological well-being, it is possible that distress and mental well-being fit along a continuum separated by a middle ground in which animals experience neither end state. This middle area might be represented by bored monkeys. Thus, one may have to do more than eliminate distress to promote psychological well-being in captive primates.

Coping Strategies

It is only recently that scientists have gone beyond the behavioral repertoire of primates to examine the individual strategies that animals use to respond to social and nonsocial events (Mineka et al. 1986). In this approach, behavior is assessed in terms of outcome and not by frequencies and durations and animals that cope effectively with various events are said to experience psychological well-being. Effectiveness is evaluated in terms of: (1) how responsive the animal is to naturally-occurring environmental events (e.g., aggression from a cage-mate) or to experimental challenges (e.g., response to change in cage location), (2) how appropriate the response is given the stimulus, (3) how effective its strategies are, and (4) what the animal's level of resilience is. Both physiological and behavioral measures can be used to monitor the effectiveness of coping strategies. At present, the link between these measures and psychological well-being has not been established.

Multiple Measures

It is clear that none of the above response systems, taken alone, serves as an adequate measure of psychological well-being in captive primates. We (Novak & Suomi 1988) have earlier proposed a tentative working definition of psychological well-being that makes use of several of these response systems as criteria. Animals are said to display psychological well-being if they exhibit at least two of the following criteria: (1) the animal is in good physical health, (2) the animal shows as much of the behavioral repertoire that is reasonably possible without compromising the first criterion, (3) the animal shows few, if any, signs of distress, and (4) the animal uses effective coping strategies. Although psychological well-being is probably some product of the above criteria, we do not yet know if these criteria are of differential importance under some conditions or if they interact with each other in unique and complex ways. Future research will be needed to determine these relationships and to winnow and sift through these and other criteria that may be developed. Nonetheless, the establishment of some sort of definition of psychological well-being now enables us to examine physical structure and to look for general prescriptions.

PRESCRIPTIONS FOR PROMOTING PSYCHOLOGICAL WELL-BEING

Another complex issue confronting both researchers and regulators is the extent to which structural changes will have broad relevance in promoting well-being both within and across nonhuman primate species. Although it has been assumed that broad general prescriptions will emerge from an examination of the data or from future studies, we believe that prescriptions will have to be tailored minimally on the basis of the species, age and rearing history of the primates under scrutiny (c.f. Novak & Suomi 1988). More importantly, current housing situation (i.e., whether a primate is maintained by itself or in social groups) will have a profound effect on the structural changes and procedures that will be needed to promote psychological well-being.

Considerations of Individual and Group Housing

If we apply our criteria for psychological well-being to both individually and socially housed animals, major differences emerge. Individually maintained primates are normally in good physical health and may be less subject to stress because of more effective management of illness and reduced risk of infection, competition and wounding (Valerio et al. 1969). On the other hand, some primates, in the absence of physical contact with conspecifics, show a reduced repertory of species-normative behavior which can be punctuated with abnormal or bizarre patterns such as rocking, swaying, clutching or self-biting (Goosen 1981). Effective coping strategies may be lacking as are the circumstances in which such skills might be developed. A different set of problems arise when assessing psychological

well-being in primates housed in social groups. Social interactions in some species may yield substantial variation in the physical health of group members. Low ranking rhesus monkeys, for example, are more likely to receive bites, sustain minor wounds, have their hair pulled out and obtain less food than higher ranking members of the social group. These effects are also relevant with respect to stress in that low ranking monkeys may experience higher levels of stress (Sassenrath 1973; Golub et al. 1979). Nonetheless, socially reared monkeys have a rich and diversified behavioral repertoire and show a variety of coping responses in contrast to their individually housed counterparts.

Different strategies must be employed for promoting psychological well-being in primates housed alone or in groups. For individually housed primates, the emphasis is on broadening the species-typical repertoire and reducing bizarre or self-directed patterns of behavior. Such changes may be effected by the use of enrichment devices which elicit species-normative responses (Bayne; Line, this volume). For socially housed primates, enrichment of the physical environment is not as important because of the high level of stimulation provided by conspecifics. Instead, the goal is to improve the health status of low ranking animals where needed and to manage the levels of stress and aggression that may exist between group members. We will now examine two strategies, increases in cage size and alterations in food delivery, which have been posited to reduce aggression in social groups.

Cage Size versus Cage Complexity

Although a number of environmental variables contribute to the expression of aggression in nonhuman primates, cage size is assumed to play the major role in modifying tensions between socially housed conspecifics. According to this view, cage size should be inversely correlated with aggressiveness. However, experimental studies of cage expansion or reduction do not always support the view that "more is better" for nonhuman primates. If "better" is defined in terms of reducing or preventing an increase in the levels of aggression between group members, then all possible experimental outcomes have been reported. Reduction in cage size has been associated with both increased aggression (Southwick 1967; Alexander & Roth 1971; Elton & Anderson 1977; Nash & Chilton 1986) and decreased aggression in nonhuman primates (Erwin 1979). Furthermore, increased cage size does not always reduce the tension and stress between group members. Harem groups of pigtail monkeys (Erwin 1979) and two small groups of rhesus monkeys (Novak & Drewsen in press) actually showed a dramatic increase in aggressiveness in response to doubling the size of their pen. Thus, there appears to be no general, direct relationship between cage size and the levels of tension between group members. A simple increase in cage size will not always promote psychological well-being in socially housed primates. A number of researchers have argued that sheer size is not as important as the complexity of the cage environment in modulating

aggressiveness (Erwin et al. 1976; Novak et al. in press). Cages are more than empty spaces occupied only by animals. Additional features of the cage environment can include solid partitions, resting perches and types of cover (e.g.,open-ended barrels). In some primate species, multilevel perches serve as different escape routes and barrels or partitions limit visual contact, thereby minimizing the effect of threats (Chamove 1984). The usefulness of these structures is dependent upon overall cage design and such designs should reflect the interrelationships between the morphology of the primate, its behavioral propensities and its ecological niche (Stuart 1981).

Alterations in Food Delivery

A substantial proportion of the aggressive interactions that occur between group members can be attributed to competition for food (Southwick 1970; Zimmerman et al. 1973). This competition may be particularly acute in laboratory animals if food is restricted to a small part of the cage (Boccia et al. 1988). Under these conditions, food consumption and energy expenditure will vary across high and low ranking animals.

A potential solution to this problem is to spread food more widely throughout the cage environment. Scattering food in a substrate or floor covering such as woodchips or woodwool increases the distribution of food and can result in reduced tension. Groups of stumptail macaques were much less aggressive during the feeding period when grain was distributed in floor coverings rather than spread uniformly or clumped into two piles on a bare tile floor (Chamove & Anderson 1988).

Dispersal of food can also be increased by making use of the vertical dimension of the cage. Reduced food competition was observed when chow was distributed in dispenser racks placed at different heights on the cage walls in contrast to scattering chow horizontally over a bare cement floor (Beckley & Novak 1988). During the rack phases of the study, rhesus monkeys were more active, climbed more frequently, hoarded food less often and expended more energy, especially when the racks were positioned high off the floor. Competition for food was markedly reduced, both because the animals were spatially separated during feeding and because no single animal could successfully monopolize more than one rack.

In addition to altering the distribution of food, both floor coverings and dispenser racks made food less visible to group members. Thus, the role of food distribution relative to food visibility in altering patterns of competition cannot be fully determined from these studies. Nonetheless, procedures for altering food delivery have been effective in minimizing food-related aggression.

Social Structure

Up to this point, we have emphasized the changes in physical structure that might promote psychological well-being in group-housed primates. However, the actual social structure may be as or even more important in modulating levels of tension and aggression between animals. Furthermore, potential changes in physical structure may have a differential impact on groups with varying social characteristics. Special consideration then should be given to the formation of social groups and their composition in terms of age- and sex-class representation. Although detailed information is available, at least for macaques, on the risks of group formation and on the dangers of introducing strangers (Bernstein 1964; Bernstein et al. 1974), less is known about the role of group composition in promoting psychological well-being in nonhuman primates. Nonetheless, physical and social structure are interrelated and strategies to promote psychological well-being in group-housed primates should consider both these factors.

SUMMARY

Recent amendments to the Animal Welfare Act will, upon taking effect, mandate that researchers who maintain primates in captivity must house their animals in a manner so as "to promote their psychological well-being." Although few would disagree with this statement in principle, putting it into practice poses several challenges.

How to define and measure psychological well-being in captive nonhuman primates is a major issue of concern. Although researchers might employ a functional approach (i.e., focusing on the animal's responses), regulators tend to have a structural orientation (i.e., focusing on cage features). However, a study of structure cannot proceed without first determining what psychological well-being is from the perspective of the animal itself. We have described a set of criteria proposed in a earlier paper (Novak & Suomi 1988) which might be used to establish the presence of psychological well-being in nonhuman primates. Mentally healthy animals are those that show at least two of these characteristics: (1) are in good physical health, (2) show a broad range of the species repertoire, (3) exhibit little distress, and (4) display adequate coping strategies. By developing some sort of definition, we can then evaluate the effects of various structural features on psychological well-being.

The other issue raised by the new regulations, that of "promoting" psychological well-being, implies that standard techniques and certain physical changes in structure (e.g., increased cage size) will have broad application to all nonhuman primates. Yet our definition reveals that different approaches must be utilized for socially and individually housed primates. Whereas the goal with individually housed animals is to broaden

their repertoire and reduce abnormal, idiosyncratic behavior, the aim with group-housed animals is to control their competitiveness and aggressiveness where needed. Furthermore, structural changes, even at this level, may not have broad application. This appears to be the case when considering the psychological well-being of group-housed primates. Increased cage size in socially housed monkeys, for example, can sometimes lead to increased aggression. On the other hand, other variables such as cage complexity and food distribution may have a more powerful impact on group aggression in some species. Finally, social structure may be just as or even more important than physical structure in promoting psychological well-being in primates housed together.

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ENVIRONMENTAL ENRICHMENT ALTERNATIVES FOR LABORATORY NONHUMAN PRIMATES

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The 1985 amendments to the Animal Welfare Act require that "a physical environment that promotes the psychological well-being of nonhuman primates" be provided. This requirement has generated much discussion of both what psychological well-being is (Novak, this volume) and how it can be improved (e.g., Line, this volume). No single prescription of environmental enrichment for nonhuman primates can adequately address the diversity of requirements of research facilities. Figs. 1 and 2 depict a flow chart which is presented for use by the investigator, veterinarian or facility manager. They suggest a variety of options for housing and managing nonhuman primates in the laboratory. These alternatives can be selected to fit a the particular research study of which the animal is a part. The relative efficacy of most of these enrichment alternatives is not known at this time. Both social and non-social strategies are presented.

SOCIAL ENRICHMENT

Contact Experience

Although a concensus has not been reached among behavioral investigators, many recommend social stimulation (pair or group housing) for enhancing an animal's environment (Chamove et al. 1973; Kraemer & McKinney 1979; Simpson 1984; Stanton et al. 1985; Novak & Suomi 1988; Novak & Drewsen in press). However, group housing limits access to animals for both investigator and animal care staff. The specific needs of all personnel should be addressed when considering this form of social enrichment. Pair housing may be a more viable alternative for many facilities due to the greater accessability to the animals. Also, modifications of current cages which allow flexibility in housing (i.e., single or pair) may not be possible.

Social housing may be full-time or part-time as animal use permits. Part-time pair housing may be applicable for studies requiring frequent handling of individual animals or requiring special dietary considerations. Recent data indicate that successful social housing can be accomplished with mixed or like ages (e.g., mother/infant dyads, peer groups, mixed age/unrelated groups or extended family units) and with mixed or same sex (Reinhardt et al. 1987; Reinhardt et al. 1988).

Partial social contact may also occur outside of the home cage in a designated exercise area through which the animals are rotated. The exercise area can include an entire room in the animal facility or can be a large pen in a separate room or an occupied animal room (thereby providing social stimulation to the animals remaining in their home cages). Round cages (Research Equipment Co., Bryan TX), which the animals can safely roll from inside the cage, may be used for exercise of the animal in the mobile cage and social enrichment of animals watching from immobile home cages. In the case of nonmoveable exercise pens, the exercise area could be equipped with devices and "toys" to increase the activity and interest levels of the occupants. If a room is dedicated to this purpose, multiple pens can be placed in the room, thus increasing the frequency of rotation of animals through the exercise area. As preliminary evidence, O'Neill (1988) indicates that different aged animals of some species (e.g., rhesus monkeys) have significantly different preferences for various types of enrichment (e.g., swinging apparatus for juveniles versus floor toys for adults). A number of alternatives should be present in each pen or different pens should be designed for various age groups. Special consideration should be given to the introduction of unfamiliar animals into the exercise area and provision should be made for only compatible pairs or groups of animals to be in the exercise area at the same time. Training the animals to a transport cage may facilitate both introduction to and removal of animals from the exercise area without anesthesia. Less stress would be imposed on the animals since they would not have to be chased back into their home cages.

The time allotted for socialization and/or exercise may be extended to become a "rest and rehabilitation" (R&R) program for certain animals (e.g., animals between phases of the same protocol, animals between protocols for the same investigator or stock animals). Rehabilitation efforts for nonhuman primates can result in various degrees of recovery of normal social behavior (Harlow et al. 1971; Harlow & Suomi 1971; Suomi & Harlow 1972; Suomi 1973; Novak & Harlow 1975; Suomi et al. 1976; Fritz & Fritz 1979; Novak 1979; Dienske et al. 1980; Huebner & King 1984). A pair could be composed of animals on R&R for the first time or composed of one naive animal and one sophisticated animal who stays in the R&R program and is repeatedly paired with new animals. Alternatively, a group of naive animals could be formed and introduced to the R&R environment. In all cases, introductions for pair or group formation must be done cautiously.

A serious consideration in social housing of nonhuman primates is the induction of separation anxiety. This phenomenon results when animals which have bonded together are physically removed from one another (Suomi et al. 1970; Suomi et al. 1976; Suomi et al. 1983). Typically the social bonding between two animals occurs early in life. The impact of separating pairs formed as adults has not been assessed. A considerable amount of variability in the impact of separation on the behavior of the

animals involved has been reported (Suomi et al. 1983), thereby underlining the necessity to take into account individual differences between animals.

Another factor which must be closely monitored is the increase in health risks for animals in social units. Clearly, the possibility of a greater incidence of disease transmission and traumatic wounds must be taken into account when considering socially housing animals which are part of a research project. A level of acceptable risk should be established by both the investigator and the attending veterinarian.

Environmental enrichment via social contact may also be achieved by interaction with human personnel. Identification of personnel dedicated to a program of human/nonhuman primate social contact must address several points. First, it should be determined whether such a program should utilize a single individual or several familiar individuals. Who should act in this role in each facility? If volunteer personnel are brought into the building, safety and liability issues must be resolved. A training program for the volunteers must be established. A security screen should be used to ensure the integrity of the building and the safety of personnel and the animal population.

Many of the nonhuman primates on active protocols already have a great deal of human contact. It is not known how much this type of contact improves the environment of the animals involved nor if auxiliary contact by individuals outside of the experimental context would be beneficial. Also, the optimum frequency and duration of each interactive period is unknown. Two possible methods of human/animal interaction include food treats and interactive devices. Because any form of interaction with the animals implies proximity between the animal and designated personnel, a program of occupational safety should be used to protect the personnel at risk.

Non-Contact Social Experience

Many instances exist which prohibit animals in a study from having direct social contact. Various methods of providing noncontact social opportunities can be used. Mirrors can be provided along walls of rooms with cages on only one side. This allows the animals to communicate with each other via reflections (Gallup 1977; Gallup et al 1980; Gallup 1982). It has been shown that many species of nonhuman primates will use social signals when viewing their own reflections in mirrors (Hall 1962; MacLean 1964; Gallup 1977; Gallup et al. 1980; Anderson 1983; Itakura 1987). Because these animals are not thought to recognize "self" in a mirror, it is possible, though untested as yet, that the "social" interaction these animals have with their reflections may have some behavioral benefit.

The importance of olfactory and visual signals for communication purposes in nonhuman primates has been clearly outlined for various species (Zeller 1987). Single housed

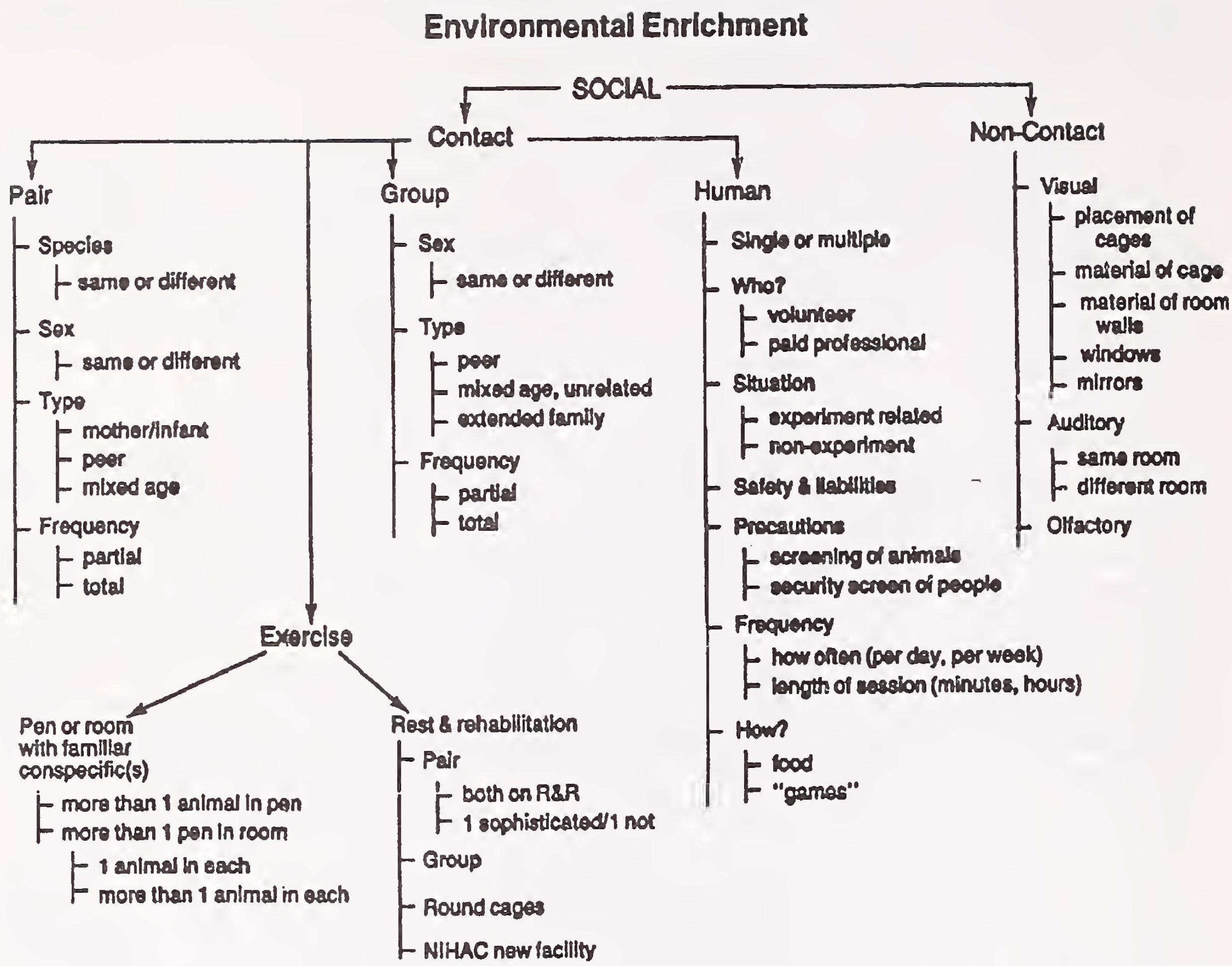

Figure 1: Options for social enrichment.

monkeys do experience a limited degree of social interaction with other animals in the room by auditory, olfactory and visual communication (Novak & Suomi 1988). Visual contact between social species may ease the stress of what would otherwise be an isolated environment if attention is paid to the arrangement of animals. However, escape from constant visual contact may be desirable for some animals. The provision of visual contact between animals can readily be accomplished by housing the animals in a room across from each other as much as is possible. Visual contact between animals can also be increased by constructing home cages out of translucent materials. Any increase in visibility between animals should be accompanied by the concommitant provision of a hiding place so that animals can choose to "escape" threatening situations or even visual contact.

Many species of nonhuman primates seem to be very curious about activities in the corridors outside their rooms; windows in the doors to the rooms provide a strong focal point for interest. The cages closest to the door should not remain empty. Rather, animals in the room can be rotated past the door so that those that benefit from this activity have the opportunity for the enrichment it provides. However, the potential for an increase in stress to "shy" animals must also be taken into account.

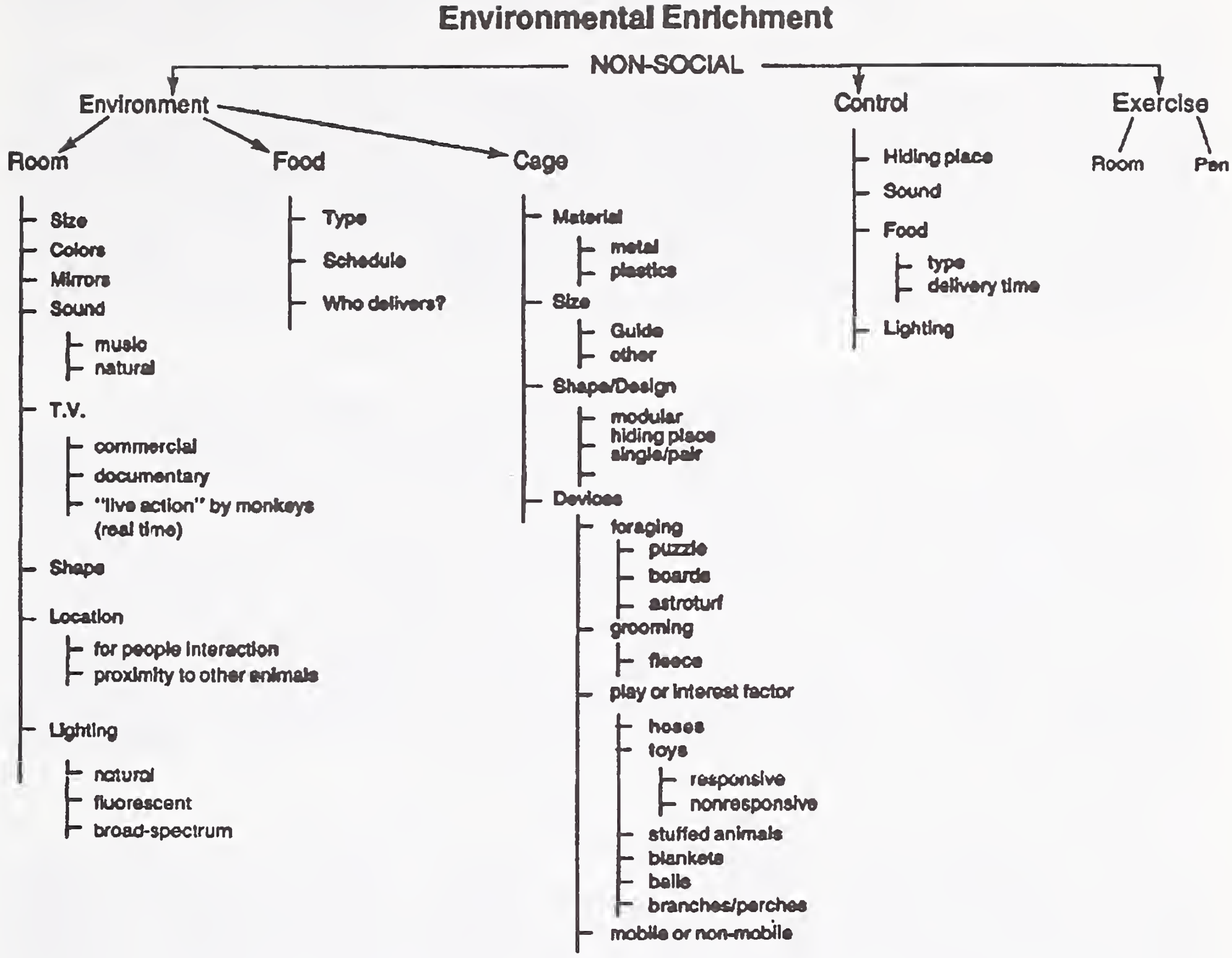

Figure 2: Options for non-social enrichment.

Much auditory communication occurs between the animals in a room. This form of non-contact social enrichment is likely to be very important to the inhabitants of an animal room. Communication between rooms might provide further stimulation for these animals.

NON-SOCIAL ENRICHMENT

The Room

Altering the room environment can be done in a variety of ways with different economic costs for each method. A simple change to the room could be changing the color of the walls (e.g., creating a jungle or plains effect). The shape of the room could be considered an important element of an enrichment program as a shape which confers more visibility between animals may be more desirable, although this could have a greater economic impact. By designing a creative shape to a room or with the placement of additional walls, animals may be able to increase or decrease their visual contact with each other by choice.

Additional features of the room which may enhance the environment of the animals housed therein include the availability of sound (e.g., music or naturalistic sounds). Research in this area is still in progress but preliminary data indicate a reduction in aberrant behaviors in some circumstances (Novak & Drewson in press). The use of television is also currently under investigation for laboratory animals. Any differences in animal responsiveness between commercial television viewing and viewing of animal documentaries needs to be determined.

Standard fluorescent lighting is usually present in animal rooms. There is evidence in both the nonhuman primate (O'Neill in press) and human literature (Mayron ēt al. 1974) that broad spectrum lighting can have a positive effect on behavior. Some components of the behavioral repertoire of group-housed animals have been altered by the use of this form of lighting (Novak & Drewsen in press). Its effect on singly-housed animals, however, is only now being investigated (Pearce & Beauchamp 1988). Broad spectrum bulbs are commercially available and may provide an easy solution to providing "natural" lighting. and skylights are also potential solutions.

The physical location of the room may prove to be a critical element of an enrichment program. Its proximity to the people working in the building may encourage authorized personnel to "visit" the room, thereby providing the animals with increased human interaction.

The Cage

At the present time there are many guidelines concerning the cage environment, and only preliminary evidence concerning the effect of cage size on the incidence of aberrant behaviors in nonhuman primates (Draper & Bernstein 1963). Recommendations on cage size and capability for sanitation are clearly outlined in the *Guide for the Care and Use of Laboratory Animals* (1985). Debate continues concerning the minimum cage size which can be the foundation for an enriched environment (Southwick 1967; Alexander & Roth 1971; Paulk et al. 1977; Elton & Anderson 1979; Erwin 1979; Nash & Chilton 1986; Novak & Drewsen in press). Until this issue is resolved, *Guide* recommendations should be considered minimum.

The design of the cage can be greatly altered by utilization of a variety of materials (plastics versus metal) and shapes (using the modular concept). Plastic materials for cage construction offer some benefits: less noise is produced by daily activities surrounding the maintenance of the cage; an opaque or translucent environment can be created without compromising the safety of the animals or the people working with the animals; plastics are warmer for the animal; and sanitation principles would not be compromised. However, plastic materials have notable disadvantages as well. They scratch more easily than metal cages, they reduce air movement within the cage and the

accumulation of waste material on the cage walls becomes more obvious thereby reducing the visibility.

A variety of sizes and shapes of the housing unit can be fashioned by creatively linking standardized modular cages. The variablity and flexibility in the design of the home environment with this kind of system could accomodate the needs of different species and ages of nonhuman primates. The provision of an escape place for each animal can easily be incorporated into a modular design. A modular design is also flexible for partial or full-time pair housing of animals.

Enrichment of the home cage environment is most commonly attempted with a variety of devices that can readily be manipulated. The presence of manipulanda has been shown to have a positive effect on a variety of nonhuman primate species (Chamove et al. 1984; Line 1987; O'Neill 1988). These devices address two main categories of behavior: foraging and play or manifestation of interest. Foraging behavior is currently being increased by the use of food puzzles, raisin boards and several substrates in which food items can be hidden (e.g. wood wool, hay, astro-turf, etc.).

The induction of play behaviors or the increase in behavioral interest (i.e., exploratory behavior) can be accomplished in many ways. The provision of cage furniture from which to swing such as ropes, hoses, chains with crates or tires or PVC piping are alternatives to consider when enriching a nonhuman primate's environment. Perches made out of cage material or wood are routinely used by nonhuman primates. Other objects such as stuffed animals and blankets are very appropriate for young nonhuman primates. Each stuffed animal should remain with an individual monkey (usually a single stuffed animal will suffice for each monkey) but the possible need for and acceptance by the infant of a replacement stuffed animal should be addressed. Blankets and stuffed animals must be made of materials which are readily sanitizable. Both objects can be cleaned in a standard washing machine. Nests made from a variety of materials such as burlap, towels, hay, etc. can be provided to animals which routinely use such structures for sleeping or parturition purposes. A variety of "toys"-- both responsive and nonresponsive-- have been shown to be used routinely by several species of nonhuman primates (Evans 1984; Westergaard & Fragszy 1985; Champoux et al. 1987; Westergaard & Lindquist 1987; O'Neill 1988) and may increase the interest level of the environment. Although it has not been tested, changing toys on a regular basis may increase the stimulation effect. The provision of a substrate which the nonhuman primate can groom in a nonsocial setting may prove to be an enriching component as this behavior in a social setting tends to have a soothing effect on both the recipient of this attention and the animal performing the grooming.

Food

Feeding time in the laboratory represents one of the most important events in the day for captive primates. Therefore, it is probable that environmental enrichment via food presentation is likely to be successful. This strategy is currently being investigated at various facilities (Bloomsmith personal communication; Nadler personal communication). Three components to the food delivery process that can be altered for enhancement of the animal's environment include a varied diet, including the judicious provision of treats (many of the commercially available treats are 100% nutritionally complete); an increase in the frequency of food delivery (either by mechanical devices or foraging opportunities); and a systematic analysis of who is the best person to feed the animals.

Control Over The Environment

It has been hypothesized by many (Mineka et al. 1986; Line 1987; Novak & Drewsen in press) that giving the nonhuman primate the opportunity to change its environment whenever it chooses to do so is a form of enrichment. Many of the features of the room and cage environment can be made flexible in presentation so that the animals can choose to alter their micro- or macro-environment. These features include sound, lighting, and food delivery time and type.

Exercise

Exercise activities do not have to be social. Many nonhuman primates will use swings and other play objects in familiar surroundings without a social partner to stimulate interest. For some animals, individual exercise periods may increase activity levels and add interest to the environment.

SUMMARY

Figs. 1 and 2 and this discussion do not provide an exhaustive listing of all possible environmental enrichment strategies available for promoting the psychological well-being of nonhuman primates mandated in the 1985 amendments to the Animal Welfare Act. Rather, they should be used as guidelines for enrichment and may even stimulate other innovative means of enhancement unique to each facility. Many of the strategies described have been anecdotally reported to produce improvement in behavior while some have been tested empirically. The selection of enrichment strategies should result from the collaboration of the investigative community, the animal care staff and the institutional officials responsible for managing the animal care and use program.

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EVALUATION OF ATTEMPTS TO ENRICH THE ENVIRONMENT OF SINGLE-CAGED NON-HUMAN PRIMATES

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The major goal of laboratory animal science since its inception has been to continually improve animal care. The focus has primarily been on physical aspects of the environment and has led to many improvements in health, nutrition and safety. The behavioral or psychological aspects of the environment have not received much active attention. This is particularly true for singly caged primates. A logical extension of the goal of improving animal care, therefore, is to enhance the psychological aspects of the environment. One way that this can be accomplished is by providing increased behavioral opportunities for animals in laboratories. Experiments designed to evaluate a variety of enhanced behavioral opportunities for primates are underway at many research facilities. This topic is also one of increasing public interest - as evidenced by the most recent amendments to the federal Animal Welfare Act which mandates provision of environments conducive to "psychological well-being" of primates.

Defining psychological well-being has thus become a necessary though difficult task. Throughout history, philosophers have attempted to define well-being as it applies to humans without reaching agreement. Attributes such as happiness, success and satisfaction are often included as part of well-being but these concepts are no easier to define and probably can't be identified in a way that applies to all. Given this state of affairs, it is even less likely that we could reach a consensus on what psychological well-being is in animals. Those who employ non-human animals as research subjects have long been aware of the negative impact that impoverished environments have on the physical health and behavioral suitability of these subjects. By the end of the 1950's, Heine Hediger had published several volumes describing behavioral and physiological pathologies associated with many captive environments along with suggestions for ways to eliminate these problems. These suggestions included increasing the amount of animal-usable cage space, providing the animal with "furniture" that would allow expression of its natural behavioral repertoire and housing naturally social species with social companions or suitable surrogates. Other workers have since examined the effects of applying some of Hediger's suggestions to the captive environments of a variety of species but an objective definition of any improvements in

psychological well-being under these modifications remains elusive (Line 1987; Novak & Suomi 1988; see also Novak, this volume; Markowitz & Line in press).

Despite these difficulties, we have a moral and legal obligation to improve conditions for the animals in our care. Abandoning the task as hopeless because of definitional problems and accepting the status quo is simply not an option. What we have attempted to do in our research with rhesus monkeys is establish an operational definition of well-being and then test it experimentally to see if the environmental changes we make have a positive effect.

We don't suggest that our idea of what constitutes well-being for these monkeys will be universally applicable or anything approaching the final word on the subject. Rather, it can be viewed as a starting point for discussion, one that has the advantage of being based on objective observation and analysis. There are huge differences between the sexes, between animals of different ages, species and developmental backgrounds and even between individuals for whom all of these other factors appear to us to be the same. Thus the general applicability of any definition or any particular strategy for enhancing well-being is apt to be limited. There is a clear need for continued research with a variety of animals and a variety of enrichment strategies.

Our approach is based in part on knowledge of species-typical behavior in natural environments. We assume that laboratory environments which promote the expression of the full range and pattern of behavior of which the animals are capable, which decrease the amount of aberrant or self-destructive behavior or which enable the animal to better cope with stressful stimuli in the laboratory are environments that promote their psychological well-being. In our research, the effects of environmental manipulations are assessed by recording a combination of behavioral and physiological dependent variables - including plasma cortisol and heart rate. We have concentrated our efforts on singly-caged macaques because this a common housing arrangement and the one that is most divergent from the environments in which these animals evolved.

This chapter describes some specific examples from the range of environmental enrichment options that have been proposed as ways to enhance psychological well-being for singly-caged non-human primates. Measurements of the effectiveness of providing monkeys with social companions, different cage sizes, simple objects or toys, foraging devices and other kinds of enrichment are included. These different approaches are illustrated with brief examples from our own work and that of others. Throughout the chapter, there is an emphasis on the importance of objectively measuring the responses of the monkeys to these manipulations. Only by careful observation and evaluation can we determine whether the changes made lead to any benefits for the animal subjects.

SOCIAL COMPANIONS

Most primates live in groups and spend a significant amount of time in social interaction. To be kept alone is thus an unnatural situation and it has long been known that total isolation leads to severe behavioral disturbances in monkeys. Most of the adverse effects are reduced, however, when monkeys are reared socially and subsequently have at least visual and vocal contact with other individuals if caged alone as adults. In general, monkeys in single cages are unable to engage in most social behaviors and thus are in a comparatively restricted environment. One of the main arguments in favor of pairing as opposed to single caging is that it allows for expression of many social behaviors, and therefore increases the range of natural behavior expressed.

Despite the common opinion that unrelated animals are unlikely to be compatible, researchers in Wisconsin have successfully paired adults and infants (Reinhardt et al, 1987; Reinhardt & Eisele 1988), adult females (Reinhardt et al. 1988), and even adult males (Reinhardt 1988). More than 90% of 29 adult/infant pairs were compatible (i.e. shared food, groomed each other and did not fight), and remained so for at least 1 to 2 years. Among 18 attempted female/female pairings, 83% of the pairs were initially compatible, and 72% remained compatible in 1 to 2 years of follow-up observation.

Pairing is not uniformly beneficial, however. It increases the risk of disease transmission and trauma. The animals usually form dominance relationships, and the subordinate partner may be subject to behavioral depression or distress. Over the long term, this could result in immune suppression and increased susceptibility to chronic disease. There are often physiological differences between the dominant and subordinate primates in a social group and these may confound the effects of experimental treatments that are being studied. For example, Kaplan et al. (1986) found that subordinate female cynomolgus monkeys (*Macaca fascicularis*) had larger adrenal size and showed enhanced adrenal responsiveness to ACTH injection in comparison to dominates of the same species. When group membership was changed periodically, dominant male cynomolgus monkeys were more likely to develop atherosclerosis than subordinate members of the same groups (Kaplan et al. 1982). These sorts of differences between animals of different rank could be a confounding factor if investigators did not take them into account during their research. There are also physiological differences between individually and socially housed animals. Shively (1988) reported that individually caged female cynomolgus monkeys had higher baseline heart rates than those kept in social groups. If a person's work is based on years of data collected from singly-caged monkeys, it may be difficult to compare those results to data from group-housed monkeys.

Another potential drawback to social housing is that there may be unexpected or adverse physiological effects. Coe

(1988) found that some immune functions were depressed in aged rhesus monkeys that were paired with juveniles. He had expected to find an enhanced immune response by pairing these normally social monkeys. The aged monkeys had been housed singly in the laboratory for a long period of time and were relatively inactive. The changes caused by introduction of young and active partners may have actually been stressful and led to immunosuppression. In another study, Boot et al. (1985) reported that singly housed cynomolgus monkeys experienced fewer losses due to perinatal infant mortality than did pair-housed females.

A number of scientists are now advocating housing all naturally social primates in pairs, if not in larger groups. For primates that have been singly housed for long periods, grouping will have to be done carefully to prevent unnecessary injury. From the standpoint of psychological well-being, social housing has many advantages. There are definite disadvantages too, though, and the costs to both the animals and researchers will have to be weighed against the benefits.

CAGE SIZE

It seems a matter of common sense that animals housed in larger cages would be better off than those housed in smaller ones. Yet this is an area in which intuitively obvious answers may lead us astray in our efforts to provide better environments for the animals in our care. Current cage size standards in the United States are based on arbitrary professional judgement, not objective study. If new regulations mandate larger cage sizes, the results will be very expensive. Estimates for the cost of implementing the new regulations that will be used to enforce the 1985 amendments to the Animal Welfare Act range from $100 million to more than $1 billion. The last public draft of the regulations would have required that any singly-caged primate that is not housed in a cage larger than the current standard size be "exercised" for 20 hours per week. Animal research facilities would have been faced with either doubling the number of animal care staff to move animals in and out of exercise cages or adding new buildings and larger cages in order to meet the regulations. Forcing research facilities to absorb these enormous costs without first demonstrating any measurable benefit to the animals. is simply not justified. Cage size is easy to measure and may be popular with regulators for that reason. Our feeling is that other factors are more important and should be given attention first. This is particularly true if large sums of money are to be spent on "improvements".

Research with primates in zoos and laboratories on the effect of enclosure size has led to mixed results. A survey of great ape exhibits in zoos indicated that environmental complexity and opportunities for species-appropriate activity were the primary factors influencing behavior while increasing enclosure size had no effect (Wilson, 1982). Play behavior in a juvenile gorilla (*Gorilla gorilla*) declined following transfer to

a larger, more naturalistic exhibit (Goerke et al. 1987). In addition, some abnormal behaviors in this animal increased while others decreased. Transfer of a group of chimpanzees from an indoor facility to an outdoor island that was larger and more complex led to a decrease in stereotyped behavior but was not associated with any increase in social behavior (Clarke et al. 1982). An increase in cage size produced greater activity in slow lorises (*Nycticebus coucang*) but had no effect on grooming or agonistic behaviors (Daschbach et al. 1982). Similarly, cage size had no effect on the occurrence of abnormal or self-aggressive behavior in rhesus monkeys (*Macaca mulatta*) but was inversely correlated with the duration of stereotyped locomotion (Paulk et al. 1977). Individually caged rhesus monkeys observed in a cage smaller than their home cage showed an increase in stereotyped locomotion while placement in a cage much larger than the home cage was associated with a complete absence of stereotyped behavior (Draper & Bernstein 1963). A more recent study did not find any changes in abnormal behavior when rhesus monkeys were housed in cages six times as large as their standard cage (Goosen 1988).

Besides strictly behavioral studies such as those cited above, there are few reports of physiological effects of cage size on laboratory primates. In one example, there was no difference in early embryonic mortality between cynomolgus monkeys that were singly housed in larger and smaller cages (Boot et al. 1985). However, perinatal mortality was higher for infants born to mothers in smaller cages and the authors concluded that reproductive success was highest for singly-housed mothers in larger cages. Pilot data from another facility indicated that cynomolgus monkeys kept in cages much smaller than the standard size had elevated levels of urinary corticosteroids (Crockett et al. 1988). As part of an on-going study of a variety of enrichment strategies for singly-caged monkeys, we examined the effect of cage size on rhesus monkeys at the California Primate Research Center (Line et al. in press). We studied ten adult female rhesus monkeys to see if increased cage size led to any change in behavior or heart rate. Subjects were placed in cages 40% larger than their standard cage for one week on two different occasions using a counter-balanced design. Seventy-five minutes of direct behavioral observations were performed per week on each subject. Heart rate and general activity of six of the subjects were monitored 35 hr per week by a telemetry system. No statistically significant differences were found in aggressive, submissive, abnormal or self-abusive behavior nor in time spent in the front half of the cage, duration of grooming, looking at the observer, stereotyped or non-stereotyped locomotion. Vocalizations increased the first time in the larger cage but not the second. The transient increase in vocalizations was probably an effect of the novel location since none of the monkeys had been moved to different cages for at least six months prior to the experiment. No differences with respect to cage size were found in heart rate or activity level. There were significant hourly changes in heart rate (repeated measures ANOVA, $p<.0001$) and activity (Friedman

test, p=.0004). These were associated with the human activity in the room and were regularly observed in both cage sizes (Fig. 1).

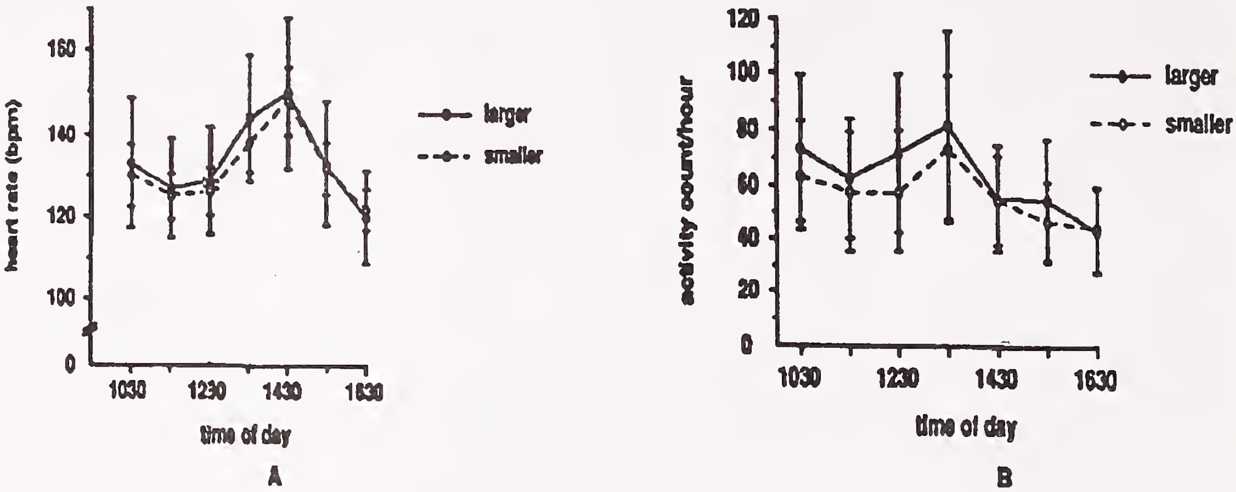

Figure 1. Mean (± SEM) heart rate (A) and activity level (B) of six rhesus monkeys. Each point represents an average of 30 samples taken over a 1-hour period. Each curve is an average of two different weeks when the monkeys were housed in smaller or larger cages.

Since we found no changes in heart rate, activity level nor in nine of ten behavioral variables, we concluded that, within the limits of our study, providing larger cages did not improve these animals' psychological well-being.

Taken together, the studies cited above suggest that there are no reliable effects of varying cage size. Given this variability, and the lack of an effect physiologically in our own experiment, cage size seems to be a relatively unimportant aspect of the environment or at least one whose manipulation is unlikely to yield a consistent and positive result. In contrast, primates do respond consistently to other events and changes in the environment. As described elsewhere in this chapter, giving them foraging devices, other types of apparatus or social companions has been shown to be effective.

TOYS AND OTHER SIMPLE OBJECTS

A variety of commercially available dog toys including large, hollow, hard plastic balls; small, hard, nylon balls (Renquist & Judge 1985; Ross & Everitt 1988) and thick rubber toys (Gilbert & Wrenshall in press) have been suggested as inexpensive ways to enhance the cages of laboratory and zoo primates. Other simple devices that have been used include a variety of novel objects (Paquette & Prescott 1988), mirrors,

plastic infant toys (Line, Clarke, & Markowitz in press), sticks (Champoux et al. 1987) and branches or PVC pipes for perching (Reinhardt et al. 1987).

Most of the literature on these sorts of devices is very limited. With few exceptions they are not reports of experimental studies and those that do include data generally were of limited duration. In the longest experiments reported, a majority of rhesus monkeys used sticks and branches for perching and gnawing over a two to three month period (Champoux et al. 1987; Reinhardt et al. 1987). Self-directed behavior declined among the monkeys given sticks for gnawing. Our experience with cage toys suggests that after a very short time (a few days or less), most macaques will lose interest in the objects that are offered. A small percentage will, however, continue to chew, gnaw, rub, carry or throw them for long periods. We are currently engaged in a 6-month project that will measure the use of nylon balls and rubber dog toys by aged rhesus monkeys. In addition, the effect the toys have on rates of abnormal behavior will be determined. To our knowledge no one has documented any long-term changes in abnormal behavior or other potential indices of well-being in primates given these types of toys. Their utility as enrichment devices remains to be demonstrated.

FORAGING DEVICES

Primates in the wild spend much of the day looking for food. Depending on the quality of the environment, the percentage of time wild rhesus monkeys spend foraging may vary from as little as 16% in urban areas where human supplements are common to over 40% in poorer habitats (Malik 1986; Seth & Seth 1986). Obviously, primates in a laboratory do not have to spend much time or energy to obtain adequate food. They are given commercially-prepared balanced diets once or twice a day. Consequently, foraging time is negligible and our observations indicate that they may spend as little as 4% of their waking time eating.

By eliminating the need to work for food, we have eliminated one of the primates' major sources of activity. The opportunity for this type of activity can be restored by providing foraging devices which allow monkeys to use their manipulative skills to obtain food rewards. Unlike the simple toys described above, monkeys do not tend to lose interest in foraging devices which offer the potential for favored foods. Several models are commercially available, and others can be inexpensively constructed from readily-available materials. Food puzzles designed for use by chimpanzees (Bloomstrand et al. 1986) or macaques (Line & Houghton 1987) have shown promising results in preliminary experiments. This type of apparatus has a series of internal levels and can be loaded with commercial monkey biscuits or other foods such as whole peanuts. The animal inserts a finger into small holes in the front of the feeder and pushes the food to the bottom level where it is removed through a

large central hole. Bloomstrand et al. (1988) reported that chimpanzees housed in groups used a food puzzle filled with peanuts for an average of 90 min after each filling over a three week period. Mean levels of abnormal behavior in the groups were not changed although there were significant increases or decreases for some individuals.

The influence of a food puzzle filled with monkey biscuits on the general behavior and appetite of five adult female rhesus macaques was evaluated in a pilot study at the California Primate Research Center. General activity, appetite, and weight were measured for four weeks with and four weeks without the device attached to the cage. All of the monkeys used the device and the number of biscuits removed increased significantly over the 4-week period (Friedman's test, p=.0104, Fig. 2). This was despite the fact that the same kind of food

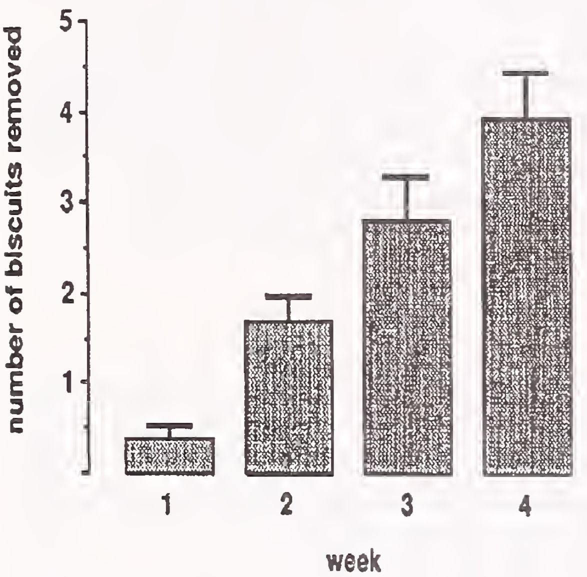

Figure 2. Use of a puzzle feeder by five rhesus monkeys. Each bar represents the mean (± SEM) number of biscuits removed per day. Ten biscuits were placed in each feeder daily.

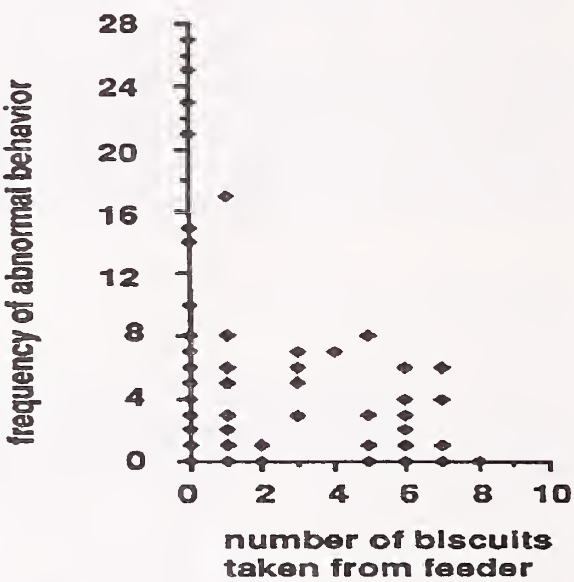

Figure 3. Abnormal behavior of five rhesus monkeys as a function of puzzle feeder use. Each point represents the number of abnormal behaviors recorded during a 15 minute session as a function of the number of biscuits removed from the feeder that day.

(although in a different shape) was available free-choice at the twice-daily feedings. There were no significant weight changes. There was a significant Spearman's correlation of -0.40 (p=.0006) between use of the puzzle feeder and the rate of abnormal behavior displayed (Fig. 3). There are several possible explanations for this result: 1) use of the feeder could have caused a decline in abnormal behavior, 2) those monkeys showing a higher rate of abnormal behavior could have used the feeder less

or 3) some other factor could have led to a lower rate of abnormal behavior among those individuals that used the feeder more. Further evaluation of this type of foraging device over a longer period of time could help differentiate among these possibilities.

Another type of foraging device that is being evaluated by a researcher at the National Institutes of Health includes crumbled pieces of favored food as a reward (Bayne 1988). The food is sprinkled on artificial turf attached to the cage floor or rubbed into artificial fleece that is strapped outside the cage. The monkeys pick through the blades of astroturf or groom the fleece to remove the food particles. Singly caged macaques will spend 30 to 60 minutes picking out the food each time it is added to the device. What effects these apparatus have on general activity and abnormal behavior of the animals are currently being measured.

Another simple foraging device is the raisin board. This is a solid block of plexiglass in which small holes have been drilled. The holes are filled with raisins or other small pieces of food and the device is then placed in the animal's cage. One brief report indicated that the board was readily used by a variety of species of Old World and New World monkeys (Moazed & Wolff 1988). Besides use, there were no other behavioral effects reported and the authors imply that it would be labor-intensive to use these boards for large numbers of animals.

Covering the floor of the cage with deep litter is another technique that has been successfully used to stimulate foraging behavior for primates housed on solid floors (Chamove et al. 1982). Sawdust, wood chips, or wood wool are placed on the floor and food (grain, nuts, fruit, etc.) is scattered through the substrate. This reduces inactivity and aggression and increases the time spent foraging. Wood chips and sawdust obviously would not be practical in hanging wire-mesh cages but wood wool has been used in this way (Bayne 1988). Sawdust or wood chips can also be placed in a box or cart outside the cage and used with hanging cages (Rosenblum 1988).

Foraging is one of the most common activities of many primate species. There is very little opportunity for most primates kept in laboratories to engage in it. Wider use of simple foraging devices could allow them to express one of their natural proclivities and relieve some of the boredom inherent in laboratory housing.

THE SEARCH FOR RESPONSIVE ENRICHMENT DEVICES

In a series of research studies at the University of California at San Francisco (UCSF), investigators constructed devices which would be potentially responsive to use by individually caged monkeys (Markowitz & Spinelli 1986). Part of

the goal was to identify devices that were attractive enough to the primates so that they would be used spontaneously rather than requiring training to acquaint the animals with new opportunities. These investigations revealed that long-term individually caged rhesus monkeys were largely unresponsive to opportunities which were readily responded to by primates maintained in social groups (Markowitz & Line in press). The types of apparatus tested were speed games (Markowitz 1982), the use of joy sticks to allow primates to splash colors across a video screen and a color and sound organ which the monkeys could operate by pulling on hemp "vines" which descended from the tops of their cages. While there was sporadic use of these devices by a few of the monkeys, none were used by all 16 animals provided these opportunities.

After considerable effort, a device which was used without training by these behaviorally "rusty" animals was finally identified. This apparatus allowed the monkeys to produce changes by simply touching one of three rods which extended a short distance into the front of their cages. They could turn music on and turn it off whenever they desired and receive banana pellets as treats. To date this apparatus has been used by all animals tested both at UCSF and at Davis (Clarke et al. 1987; Line et al. 1987; Markowitz & Line in press; Line et al. in prep). Current work on this project involves detailed assessment of both behavioral and physiological results of ad lib use of this apparatus. Among the initial statistically significant behavioral findings are the reduction of abnormal behaviors and reduction in excessive grooming in periods when the device is available to animals. Basal plasma cortisol levels are also significantly reduced in periods with the enrichment apparatus available which, based on human clinical literature (Das & Berrios 1984; Ceulemans, Westenberg, & Van Traag 1985), would suggest that the monkeys are less behaviorally depressed.

In addition, we are collecting and analyzing a variety of additional physiological measures such as heart rate and cortisol changes in response to routine events including cage changes and brief restraint. These responses will be measured both with and without the enrichment apparatus present. We are currently completing work on an interface which will permit many other researchers to incorporate use of the enrichment apparatus in their experimental protocols. The interface will allow a computer to be directly connected to the apparatus for control of input and output parameters and will provide for the use of alternative reinforcement devices. We have identified the fact that a number of researchers may be able to accomplish significant parts of their research without excessively disturbing the animals by removing them from their home quarters. Preilowski and his research group in Germany have shown that it is practical and effective to combine enrichment procedures with demanding, complex research designs. Studying laterality of function in rhesus macaques, they had traditionally removed animals from their cages and made measures in surroundings that were foreign to their subjects. By providing monkeys with

methods to control their own feeding in their home cages and then using these same feeding devices to reinforce the animals during experimental testing, they were able to accomplish two significant results. The primates showed reduced abnormal behaviors thus suggesting that they were more appropriate experimental subjects and the research measures were more sensitive than with previous protocols (Preilowski et al. 1988).

Many other researchers are working to assess the effectiveness of enrichment methods that do not require special apparatus. Although the results of most of the studies are reported in a preliminary fashion, some of these potentially useful methods of enrichment will be attractive to institutions that have sufficient personnel to allow significant periods of interaction with animals in their charge. For example, Bayne (this volume) has suggested that positive human interaction may represent an effective means of enrichment and Desmond (1988) has found that positive interaction with humans leads to reduction in aggressive behavior in drills. Bloomstrand et al. (1987) have reported that providing a variety of foods in a "natural" fashion may serve as a form of enrichment.

SUMMARY

Although most of us may agree that it is important to provide richer environments for those animals that serve as research subjects, it is not sufficient to simply make changes which seem to us as if they should be attractive to the animals and reduce the deleterious effects of confinement. Active programs of assessment are necessary if we are to identify truly enriching regimens which will increase the well-being of our research subjects. There are difficult issues to be addressed in finding methods which will provide necessary access to animals for research and simultaneously allow more active, healthy lives for these subjects. In addition to moral obligations that some of us may feel require acceleration of the efforts to enrich the lives of animals kept in captivity for our use, there are significant scientific reasons to strive for subjects that are more healthy representatives of their species. The limited data available to date suggest that a wide variety of approaches to environmental enrichment may be of value. In order that we may ultimately be cost effective in our efforts and simultaneously provide measurable improvements in the lives of our subjects, intensive scientific evaluation of various approaches to enrichment is necessary at the outset.

NOTES

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